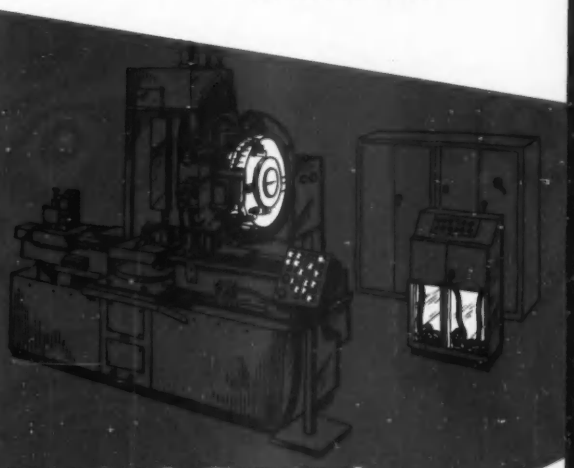
Control ENGINEERING

INSTRUMENTATION AND CONTROL SYSTEMS

A McGraw-Hill Publication

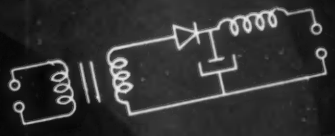
75 Cents

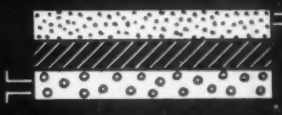
MARCH 1960



What's New

Numerical Control is K & T's Star





Molecular Electronics for One-Piece Systems

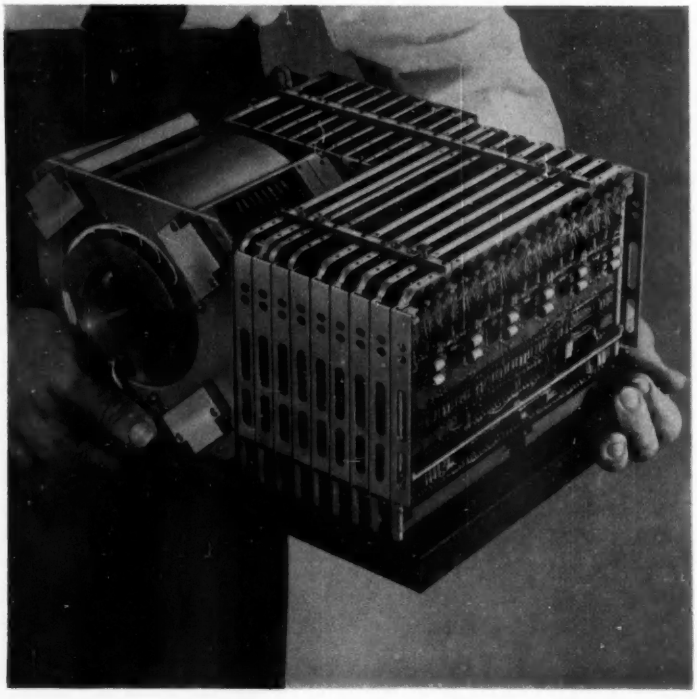
Timers Control Scent in New Movies

PLUS—
Control Engineer's Guide to IRE Sessions

LIBRASCOPE AIRBORNE COMPUTERS

What goes up must fly true. To maintain this condition, Librascope has packaged the rectangular, polar and spherical geometries of flight...in computers easily held in a man's hand or held aloft by an economic expenditure of power...computers unexcelled for 22 years at calculating flight paths, interception courses, fire control trajectories...with answers that come out fast and right. They offer a challenging capability to alert project and design engineers. Write to Librascope, 808 Western Avenue, Glendale, Calif. For engineering career opportunities, address Glen Seltzer, Employment Mgr.

computers that pace man's expanding mind



GP LI-04

CIRCLE 229 ON READER SERVICE CARD

Here are America's first six CE-Sulzer once-through boilers: All have L&N Direct-Energy Balance Control.

Company	*Station*	*Operating Pressure (psig)*	*Capability*
Dayton Power & Light Co.	Tait 4	2400	150 MW
Metropolitan Edison Co.	Portland 1	2400	165 MW
Dayton Power & Light Co.	Tait 5	2400	150 MW
Philadelphia Electric Co.	Eddystone 1	5000	325 MW
Cleveland Electric Illuminating Co.	Avon 8	3500	250 MW
Philadelphia Electric Co.	Eddystone 2	3500	325 MW

New L&N Direct-Energy Balance Control Coordinates Once-Through Boiler and Turbine

Philadelphia Electric Company's Eddystone Unit No. 1, the world's highest pressure and temperature (5000 psi and 1200°F) steam generator, employs the largest CE-Sulzer, once-through boiler ever built.

A new type of combustion control, Direct-Energy Balance, coordinates boiler-turbine operation by considering them as an integral unit. From combined steam pressure and generator intelligence, D.E.B. controls regulation of both fuel input and turbine governor valves. Excess air is "trimmed" automatically by flue gas oxygen analyzing equipment.

In the picture above, an operator at Eddystone is using the D.E.B. Control to set directly the desired rate of generation change. When he calls for a change in load, the control responds quickly, at the pre-set rate of change. Operation of the unit is integrated because (1) boiler-turbine output is changed in a predetermined, orderly manner, and (2) output is kept within the capabilities of the equipment in service.

In designing the Direct-Energy Balance method, L&N engineers sought a basic improvement over conventional combustion controls. Based on 30 years' experience in power plant measurements and controls, this new method was developed, subjected to simulation studies, and extensively field-tested. Direct-Energy Balance Control has also been selected for Unit 2 at Eddystone, a supercritical unit of 3500 psi. For information on this new concept in combustion control, call your nearby Field Office, or write for Reprint 463(8) to 4918 Stenton Avenue, Philadelphia 44, Pa.

Direct-Energy Balance Control ... engineered to power plant standards by **LEEDS & NORTHRUP**
Instruments — Automatic Controls • Furnaces

Control ENGINEERING

MARCH 1960
VOL. 7 NO. 3

Published for engineers and technical management men who are responsible for the design, application, and test of instrumentation and automatic control systems

Continued on next page

What's New in the Control Field

PRINT ORDER THIS ISSUE 34,164

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Postmaster: Please send form 3579 to Control Engineering, 330 W. 42nd St., New York 36, N. Y.

Solid State Reliability IN A 10 mc Counter

The CMC 700 Series is the only major breakthrough in counting, timing and frequency measuring equipment in the past 10 years. Here is the first successful application of transistors to high frequency counting and timing. Transistors perform all the functions in CMC's 700 series that required 63 tubes in old style counting equipment. These are the most reliable counters ever made.

TRUE DIGITAL LOGIC CIRCUITRY

By answering an obvious need for a completely new, up-to-date approach to counting and timing instrumentation, CMC has produced solid state instruments with greatly simplified circuitry, using logic "and" and "or" gates.

LIGHT AND SMALL, LOWER POWER DRAIN

Each 700 series instrument weighs only 27 pounds, measures 7 inches high, 17 inches wide, and 14 inches deep. Power consumption is a meager 46 watts, 1/10 the amount for vacuum tube models.

DO ALL THESE JOBS

Measure frequency from dc to 10 mc, time interval from 0.1 μsec, ratio 1 cps to 1 mc and unlimited multiple period selection. Frequency converters available for higher frequencies. The counter also generates time interval marker pulses from 1 μsec to 1 second. Data can be presented on standard decades or inline Nixie tubes. The 700 series will operate digital recording equipment, punches, inline readouts, and other data handling gear.

These Features, Too—Decade count-down time base—frequency divider circuits never need adjustment. Accuracy, ±1 count ±oscillator stability. Sensitivity, 0.25 v rms; input impedance, 25 k ohms/volt.

And The Price—Higher than vacuum tube models. But you can save the difference on down time in the first year. Model 727A Universal Counter-Timer, $2,750; Model 707A Frequency-Period Meter, $2,575; Model 757A Time Interval Meter, $1,975. Rack mount optional at no extra cost. All prices f.o.b. Sylmar, California.

More Information Available – Your nearby CMC engineering representative will be happy to arrange a demonstration and provide you with complete technical information. Or you may write Department 08-3.

Computer Measurements Co.
A Division of Pacific Industries
12970 Bradley Avenue, Sylmar, California
Phone: EMpire 7-2161

CIRCLE 5 ON READER SERVICE CARD 5

SHOPTALK

International flattery

Apparently control engineers in at least two countries besides the U. S. thought that Associate Editor Harry Karp's treatise on electronic process control systems (see CtE, November '58, pages 81-96) was a contribution to the literature. Substantial reference was made to Harry's article in Japan's *Journal of the Society of Instrument Technology*, November 1959 electronic controller issue, and it was recently brought to our attention that the Russians published a special 10-page abstract of the paper.

More talk about numerical control

Managing Editor By Ledgerwood takes the podium again on March 22 to expound on his favorite subject—numerical control of machine tools. As one of a four-member panel at a Cleveland production activity meeting of the SAE, By will discuss the future of numerical control, its application to other than metalworking machinery, and the integration of the recorded-instruction concept into the overall manufacturing operation. Moderator is Bob Colten of General Motors; the other panel members are Peter Tilton of Stanford Research, Ernest Newman of IBM, and James Rankin of Convair.

Make it $imple

This motto hangs in Maj. William L. Still's office at the Air Force Ballistic Missile Div. of ARDC, Inglewood, Calif. Its object: to continually remind the major that his job as Project Officer responsible for the ground electronics and communications for the Minuteman ICBM is to keep things as simple and reasonably priced as possible within set performance limitations. (An attitude sincerely welcomed by taxpaying citizens.) Prior to his Minuteman assignment, Major Still did his basic work on probability filters (see "Separate Signal from Noise with Probability Filters", page 31) as assistant chief, Analysis and Design Branch of the Guidance Laboratory, WADC. His engineering education was obtained entirely within the Air Force: both a B.S. in aeronautical engineering and an M.S. in E.E. from the USAF Institute of Technology.

Forthcoming in April

A quick look at some of the choice items to be featured in the April issue: guide to controlling continuous-flow chemical reactors, novel gyro caging scheme makes versatile stable platform, tricky system automatically trues bicycle wheels, how to pick and use proximity switches, and statistical data reduction and control systems.

300 HOUSINGS PER HOUR
produced on Greenlee machine— with assist from VICKERS hydraulics

Here's a Greenlee transfer machine that produces 300 steering gear housings per hour while performing a total of 114 close tolerance machining operations. This outstanding performance record is achieved because the machine combines advanced design ideas with the best available components.

Self-contained Vickers hydraulic power packages provide controlled power for clamping the pallet-mounted workpieces in precise position at each work station, driving transfer mechanisms and for movement of certain machine heads. These power packages are designed to JIC (Joint Industry Conference) standards which means easy maintenance and minimum downtime to you.

Vickers offers you power packages, either standard or custom engineered that provide an almost unlimited number of choices to meet your specific technical requirements. You can choose from the broadest product line in the industry any combination of controls for use with single, double, two-pressure or two-stage pumps (the latter for pressures to 2000 psi), and for variable and constant delivery pumps to 5000 psi. Your choice of components will be packaged with the size or shape reservoir best suited for your job.

Whether the Vickers power package you choose is standard or custom engineered, you save money and time because it comes *ready-to-go*—designed and assembled to the highest standard of quality by hydraulic specialists.

Get more data by writing today for Bulletin 5001C or by consulting your nearby Vickers application engineer.

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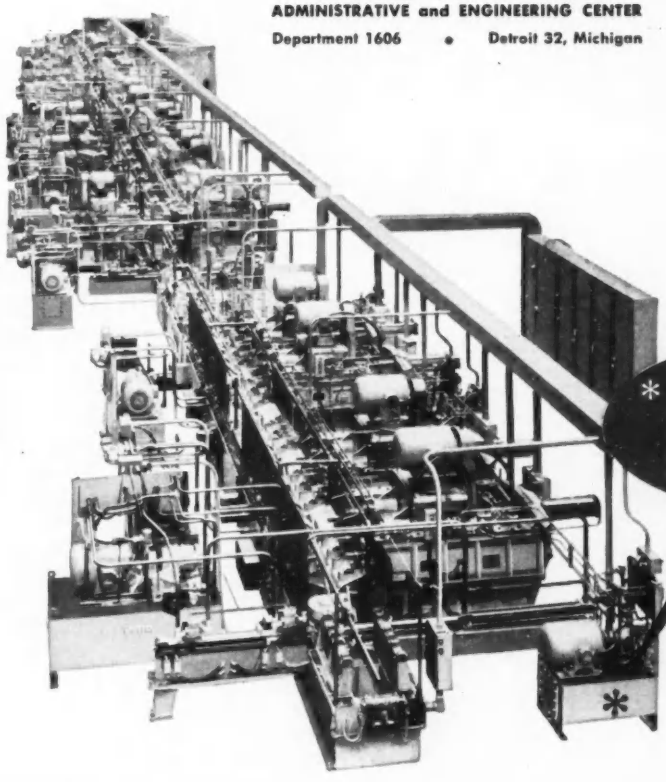
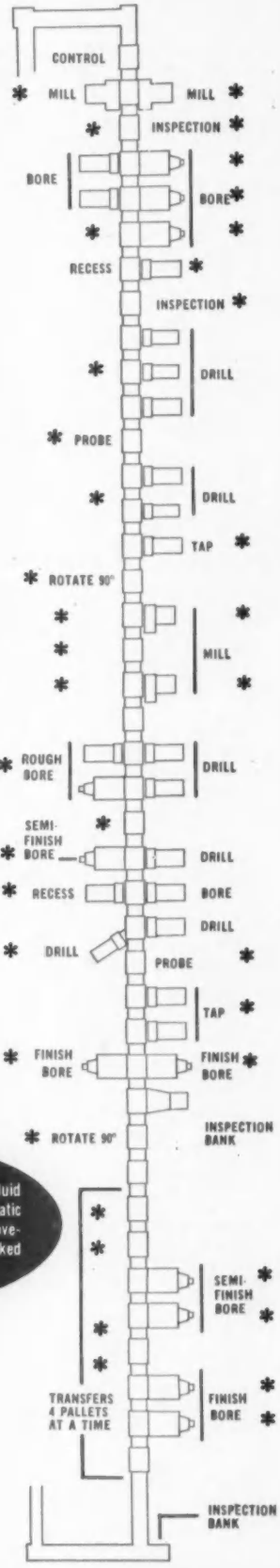


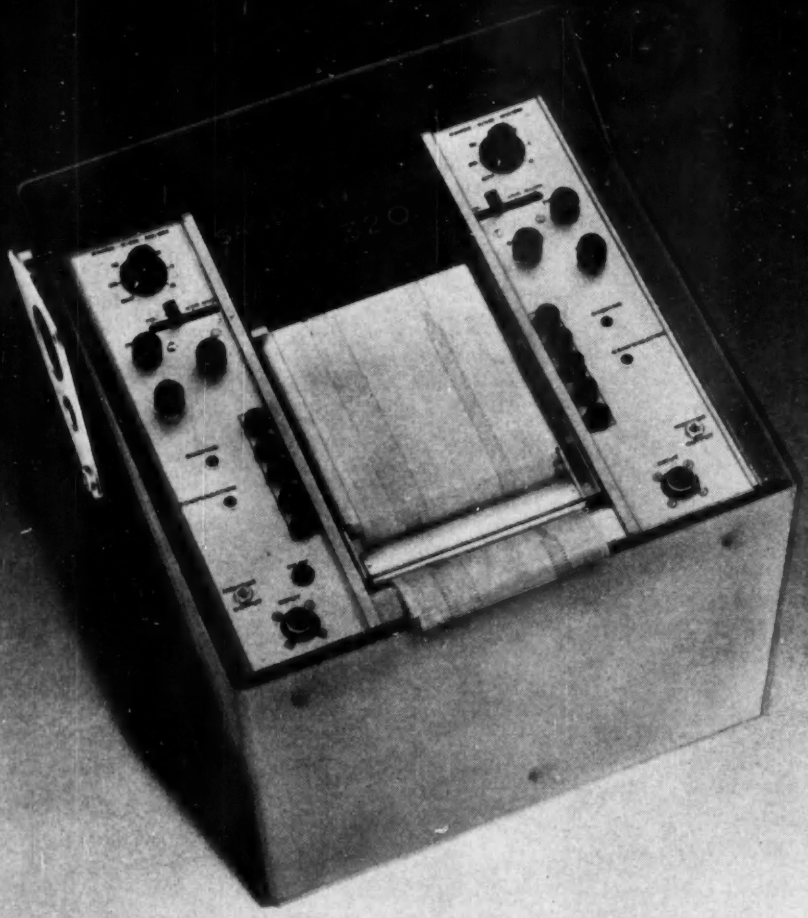
* Vickers power packages supply fluid energy for fast, precise, automatic clamping, transfer and head movement at station locations marked with asterisk.

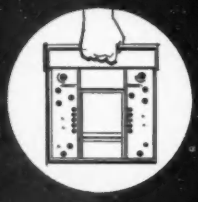


NEW

MODEL 320

PORTABLE 2-CHANNEL...





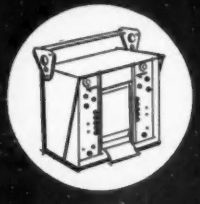
MEASURING

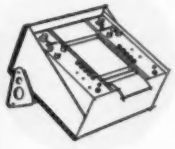
FEEDBACK

The new Sanborn Model 320 system — for general purpose DC recording in any part of the plant or on field assignments — combines rugged current-feedback amplifiers, 2-channel recorder assembly and dependable all-transistor circuitry in less than a cubic foot of space. And the many advantages of Sanborn multi-channel systems are incorporated in the new portable 320 — low impedance, enclosed galvanometers; clear, permanent traces made by heated styli; rectangular coordinate charts. Most components for each channel are mounted on one easily serviced card; others are readily accessible. The control panel permits easy access to the controls for each channel . . . provides for observation of 6 inches of the chart . . . and it can be set up for use vertically, horizontally or at a 20° angle using the adjustable stand/carrying handle.

Your nearest Sanborn Sales-Engineering Representative can provide you with complete data or write the main office in Waltham. Sales-Engineering Representatives are located in principal cities throughout the U. S., Canada and foreign countries.

DIRECT WRITING SYSTEM





- **up to 0.5 millivolt/mm sensitivity**
- **inputs floating and guarded for each channel**
- **rectangular coordinate charts full 50 mm wide**
- **only 12¾" square, 8¾" deep**
- **4 pushbutton chart speeds**
- **completely transistorized**

SPECIFICATIONS

electrical

Sensitivity Ranges . . . . 0.5, 1, 2, 5, 10, 20 mv/mm and v/cm
Input Impedance . . . . ½ megohm on mv/mm ranges and 1 megohm on v/cm ranges
Frequency Response . . . . . , 3 db down at 125 cps, 10 div peak-to-peak
Common Mode Voltage . . . . . ± 500 volts maximum
Common Mode Rejection . . . . . 140 db minimum DC
Linearity . . . . . maximum non-linearity — 0.2 mm with respect to chart center
Calibration . . . . . 10 mv internal signal ± 1%
Limiting . . . . . approx. ± 115% of full scale
Rise Time . . . . 4 milliseconds with less than 4% overshoot

physical

Input Connectors . . . . . separate for each channel
Output Connectors . . . . 40 mv/mm sensitivity for connection of external monitoring scope to each channel
Dimensions . . . . . approx. 12¾" by 12¾" by 8¾"
Weight . . . . . approx. 55 lbs.

Controls
(for each recording channel)
Range Switch . . . . . 6 positions and off
Smooth Gain Control
Function Switch . . . . 4 positions — Zero, Cal, Use mv/mm
Position Control — Use v/cm
Stylus Heat Control

Galvanometer Damping
Galvanometer Compensation (screwdriver adjusts.)

(for the entire system)
Power ON-OFF
Speed Control . . . . . 1, 5, 20, and 100 mm/sec
Marker-Off-Timer

Data subject to change without notice.

See this new System at the I.R.E. Show—Booths 3601—03—05

SANBORN COMPANY

INDUSTRIAL DIVISION 175 Wyman Street, Waltham, Massachusetts

CIRCLE 9 ON READER SERVICE CARD

CHECKUP on your Control Valves

FEEDBACK

READERS' CONTROL WORKSHOP

What, simulation of stiction is a pot-boiler? January issue feedback from England on an article published in the Oct. '59 issue demonstrated the latent heat of the topic. And now a reader in Indianapolis brings the pot to a boil with feedback on feedback. Submit your problems, solutions, and advice on pitfalls. If published, they earn honorariums.

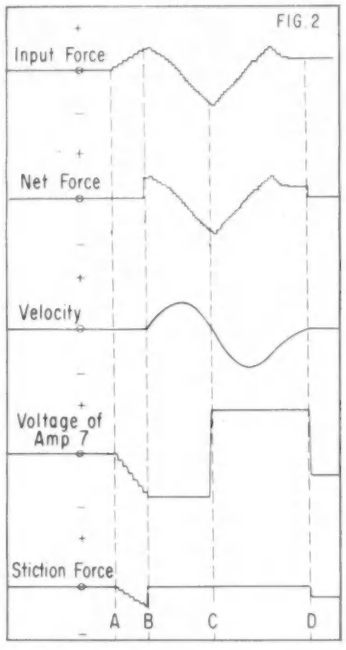
To the Editor—

Congratulations to Mr. Taunton of Bedford, England for his excellent Stiction Analog given in the January issue of your publication. [p. 10].

Our analysis indicates that the circuit should work in the desired manner. To us it seems that Mr. Taunton's feeling that the circuit should not correctly simulate stiction when velocity approaches zero and then increases again is unwarranted. We feel that it should operate correctly in this instance also. The only thing which can cause nonideal operation is the fact that the diodes are never ideal.

Some of your readers may be interested in a circuit used at Allison and shown in my Figure 1. Equipment requirement is one amplifier and relay. If the physical system has static friction present, the requirement reduces to a relay—since a tie from the output of Amplifier 7 to Amplifier 4 simulates static friction. The feedback resistor in Amplifier 7 is necessary to insure that the relay has time to fall out when velocity crosses zero. The resistor causes the circuit to give nonideal simulation of stiction.

However, operation is pretty good,



as indicated by the recorded curves in my Figure 2. Between points A and B, input force increases and is balanced by stiction force; net force and velocity remain zero. At B stiction is overcome, net force leaps up, and velocity starts increasing.

At point C velocity reaches zero, causing stiction to grab. However, input is greater than stiction, leaving a finite net force. Hence system crosses zero velocity without stopping.

At point D, velocity becomes zero,

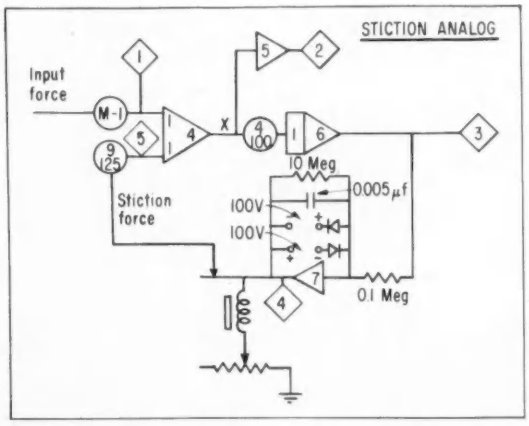


FIG. 1. In this circuit diagram of a stiction analog, diamonds signify recorder channels. Circles identify coefficient potentiometers; for instance, potentiometer 9, set at 0.125.

CHECKUP on your Control Valves... CHECKOFF these Annin Advantages*

***Any other source might give you a few... but with Annin you get them all!**

MINIMUM number of parts per complete valve.

OVER 60,000 successful case histories of split body valve applications.

POSITIONING ACCURACY guaranteed, .001 inch per inch of stroke.

CONSTANT INSTRUMENT signal sensitivity throughout signal range.

COMPLETE INTERCHANGEABILITY of any Domotor valve to on-off pneumatic control, pneumatic hydraulic, electro hydraulic, electro pneumatic or manual actuator.

ENGINEERED FOR MANUAL control with any of the above automatic actuators, if desired, at minimum cost.

SIMPLIFIED ADDITION of high speed booster units to any pneumatic positioning actuator.

ADAPTABILITY of bellows seal, doolseal or plain extension to any standard valve.

BODY SIZES from ¼" up.

COMPLETE LINE of body ratings: 600—1500—2500 lbs. ASA; special 10,000 and 60,000 psig design, temp. —450°F to 1600°F.

CONVERSION FROM globe body to angle body construction with only one additional part.

ADAPTABILITY TO 3-WAY Valve Construction with minimum parts and cost.

MINIMUM COST for change from soft seat construction to hard seat, or vice versa.

First in a series of checklists on Annin features.

Annin **VALVES**

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1040 South Vail Avenue
Montebello, California

FEEDBACK

but stiction is greater than input. Hence, system locks.

Attention is drawn to the slight positive pip in the stiction trace and in the net force trace at point D. This is error due to the finite feedback resistor across Amplifier 7. The error is not considered serious.

R. O. Whitaker
Allison Div.
General Motors Corp.
Indianapolis, Ind.

Idea became hardware months ago.

To the Editor—

I recently read your excellent September issue and noted a small story on the bottom of page 175 entitled "Statistical Telemetry—A New Way to Save Bandwidth". I take no issue with what Mr. Westneat [Gulton Inds.] says but would like to correct the impression (implied in his article) that statistical telemetry is a new idea, just now being developed, as well as his statement that hardware is not yet available.

The facts are that ASCOP, over a year and a half ago, recognized the concepts back of statistical communications and began development programs to build just the type of equipment mentioned in Westneat's story. To my knowledge, ASCOP was the first company to apply these principles successfully. About a year ago working prototypes of some units were available, and for the last ten months ASCOP has been selling statistical space telemetering equipment:

1. A time-of-occurrence marker generator
2. Power-frequency spectrum analyzers
3. Amplitude probability distribution analyzers
4. Dual power-spectrum and amplitude distribution analyzers.

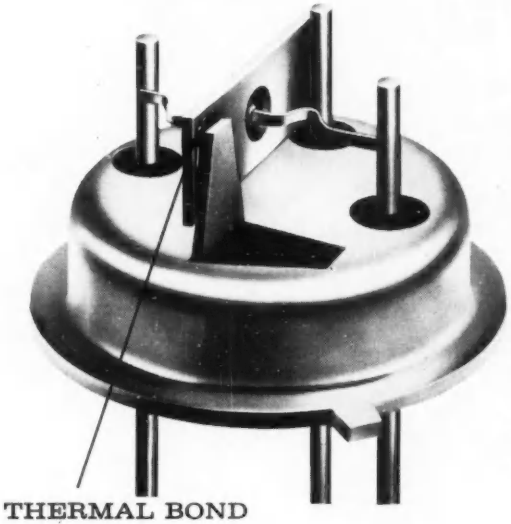
These units are all designed for airborne or missileborne applications. Among the major programs using them is National Aeronautics and Space Administration's Project Mercury.

In addition, ASCOP has successfully built and tested a prototype airborne correlator and, supported by government funds, is actively pursuing research into transfer function computers capable of handling random inputs. A model has been successfully demonstrated.

John F. Moore
Applied Science Corp.
Princeton, N. J.

5 GUARANTEES

for Tung-Sol 2N1313 Computer Transistor mean new freedom for designers



- GUARANTEED DESIGN CENTER VALUES OF ALL MAJOR PARAMETERS
- GUARANTEED MIN-MAX LIMITS FOR ALL MAJOR PARAMETERS
- GUARANTEED DISTRIBUTION OF ELECTRICAL DESIGN CHARACTERISTICS
- GUARANTEED DISTRIBUTION OF SWITCHING TIMES
- GUARANTEED UNIFORMITY OF EVERY LOT

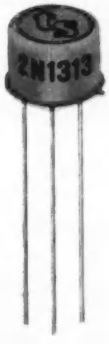
And there's still another. For a nominal additional charge any specific electrical design characteristic will be 100% guaranteed not to exceed its distribution limits. These guarantees add up to a marked upgrade in circuit design accuracy . . . high reliability in operation . . . and consistent repeat performance. In specifying the Tung-Sol 2N1313 high speed switching transistor, you're selecting a transistor which features an ideal balance of the most wanted characteristics as revealed by a survey of computer designers. You're also choosing a transistor which offers improved performance at lower cost over most of today's popular computer types.

The 2N1313 is designed to meet vigorous military environmental standards. It features "Thermal Bond" construction, exclusive with Tung-Sol. The transistor junction tab is securely joined to the base of the transistor. The bonding material provides high heat dissipation while maintaining complete base-to-case electrical isolation.

Tung-Sol Electric Inc., Newark 4, N. J. SALES OFFICES: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Texas; Denver, Colo.; Detroit, Mich.; Irvington, N. J.; Melrose Park, Ill.; Philadelphia, Pa.; Seattle, Wash.; Montreal, Canada.

Absolute Maximum Ratings (@ 25°C)

BV_{CBO} .....−30 Volts
BV_{EBO} .....−20 Volts
BV_{CEX} (V_{BE} = 0.1V).....−20 Volts
BV_{CEO} .....−15 Volts
I_C (continuous).....400mA
I_B (continuous).....50mA
T_j .....−65°C to +100°C
P_C 180mW



Typical Characteristics (@ 25°C)

Parameter	Conditions	Min.	Design Center	Max.	Units
I_{CBO}	V_{CB} = −0.5V	—	1.5	2.5	μA
I_{CBO}	V_{CB} = −15V	—	2	3.5	μA
h_{FE}	I_B = 1mA, V_{CE} = −0.25V	40	70	125	
h_{FE}	V_{CE} = −0.35V, I_C = 400mA	20	30	50	
f α b	V_{cb} = −6V, I_C = 1mA	6	12	—	Mc
C_{OB}	V_{CB} = −6V, I_E = 1mA, f = 1Mc	9	14	20	μμf
($t_r + t_d$) (rise plus delay time)	I_{B1} (turn on current to base) = 1mA	—	0.45	0.70	μsec
t_s (storage)	I_{B2} (turn off current) = 1mA	—	0.30	0.60	μsec
t_f (fall)	I_C = 10mA, R_L = 1K	—	0.25	0.40	μsec

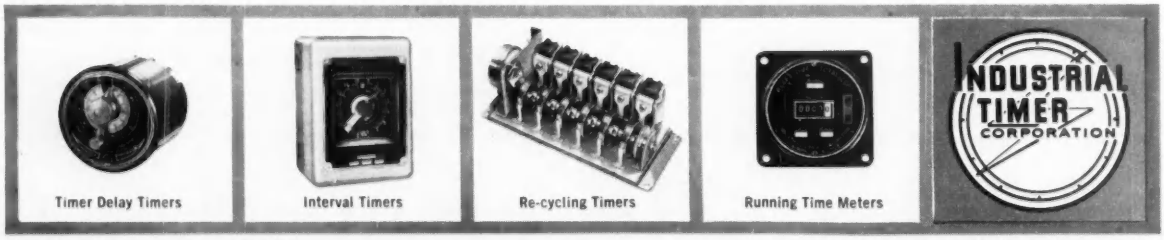
TUNG-SOL®

CIRCLE 13 ON READER SERVICE CARD 13

we control even this kind of timing!

Timing is a matter of life and death in a hatchery. Every egg must be gently rolled every 60 minutes the way a hen does it: with gentle unfailing precision. And while a hen's instinct tells her just how to evenly expose each part of the egg to exactly the right amount of warmth, in a modern hatchery it's one of our re-cycling timers that does the job. And in a way that reproduces instinct.

You'll find many other examples of Industrial Timers that solve problems with equal precision in our general catalog. For, in solving numerous timer problems we have developed over 2,000 timer combinations. One of these will most probably be the timer *you* need. And our large stock always assures you of rapid deliveries. See for yourself. Send for our general catalog today.



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G.L. Hollander

Adds something to computer control

At the 1960 AIEE winter meeting the subject of computing-control occupied a prominent place on the program. Three separate sessions were devoted to presentations in this activity. One of the driving forces behind this new AIEE interest is Gary Hollander, a tall articulate computer specialist at the Philco Corp.

During one of these AIEE sessions, listeners heard the first description of the LN 3000 computer control system, a joint project of Philco Corp. and Leeds & Northrup Co. And behind the conception of the computer part of this system was this same Gary Hollander.

Although he's only 38 years old, Hollander is entitled to the sobriquet of a self-made man. His climb to his present position of Section Manager, Systems Management at Philco has been punctuated by more than the usual hardships and roadblocks.

Fresh out of high school in Germany, young Gary Hollander arrived in the United States alone with only a few dollars in his pocket and the added handicap of not being able to speak English. He spent one year at an American high school while he supported himself in a variety of odd jobs that ranged from delivering newspapers to filling shelves in stores.

By the end of a term, he spoke English well enough to stand at the head of his English class. In 1938 he entered the Illinois Institute of Technology to study electrical engineering. But nine years were to pass before Gary was to win his degree. Economics forced him to retire from IIT after two years.

Interestingly, his enforced withdrawal introduced him to the wonderful world of electronics. Employed in a store, Gary worked his way up to the position of a buyer of radios in one of Chicago's mail order houses. In 1943 he joined the U. S. Navy and because of his exposure to electronics found himself in the Navy's radar program. Before he was discharged, he helped introduce into the fleet the Mark 57 and Mark 63 fire control system, the anti-Kamikaze defense which the Navy first built itself.

Finally out of the Navy, Gary returned to IIT to complete his education; he earned his BSEE degree in 1947. His first job after graduation turned out to be shortlived. Hired by McDonnell Aircraft to work on an early missile project, Gary found himself drafting parts when the project folded before it really started.

Used to battling hardships, Hollander took his setback in stride, found a place for himself on the faculty of St. Louis University as an assistant professor of engineering. While he was helping to establish an electrical engineering curriculum there, he was earning his master's degree in electrical engineering at Washington University.

In 1949 he moved to Boston where he went to work at Raytheon and continued his schooling at MIT. At Raytheon he was a senior engineer in the servomechanism laboratory, and he developed a variety of servosystems and designed analog computers.

Three years later he joined the staff of MIT to work in the Servomechanisms Laboratory. It was here that he first met digital computer work. In 1954, after earning the MIT degree of Electrical Engineer, Gary joined the Clevite Corp. to set up a computer section. One of the items his group perfected was the magnetic Tape-DRUM for large quantity storage of data.

He joined the Philco Corp. as section manager, Control Computer Systems, in 1957. In this position he was responsible for the development of the Philco C-1100 airborne computer series and the C-3000 industrial computer (which is incorporated in the LN-3000 computer control system).

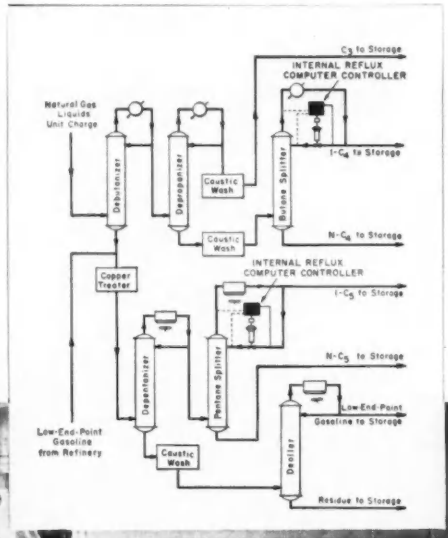
But what may be Gary's biggest contribution to computing-control still is unpublished. He is working on an analytical technique for determining the optimum computer configuration to provide most economic control of a process. After a few specified computer and process characteristics are fed into a computer program, suitable computation produces specifications for the most economic computer for the job.

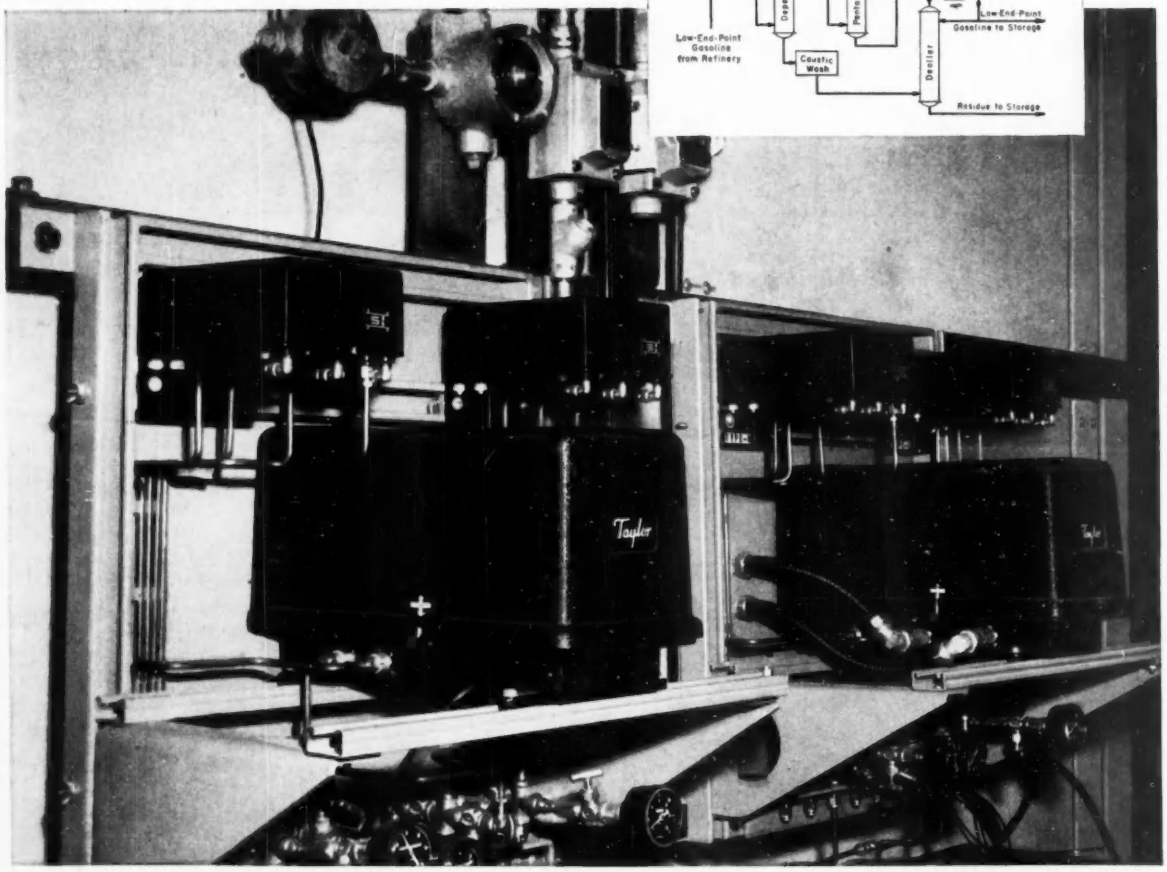
Gary's varied talents have kept him busy outside the office too. In Boston, his deep resounding bass voice was good enough to earn him a singing spot with the chorus of the Boston Symphony Orchestra. He is an ardent swimmer and tennis player. All these activities he shares with his wife Marianne. Along with being chairman of the AIEE's Computer Systems Committee, Gary is a manager of the Philadelphia section of AIEE and active in the IRE.

MORE PROFIT PER

Drawing at right shows the Taylor Internal Reflux Computer System, installed at Phillips' Sweeny, Texas, Refinery on LP gas fractionation columns. It can be supplied with either pneumatic or electrical output. It fits into any control system already installed—also into any large scale digital or unit analytical computer installation. Set point can be adjusted manually by the operator or automatically from column temperature, process analyzers and/or computers, etc.

Components are all standard, proven units. The Taylor Potentiometer Transmitter permits the use of thermocouples in place of special resistance elements for narrow span differential temperature measurement.





Taylor Computer-Controllers in use on the light ends fractionation system, typical of several systems in use as shown in drawing above.

Taylor Instruments

BARREL OF PRODUCT...

Phillips Petroleum Co. reports optimum fractionator efficiency with Taylor Internal Reflux Computer Control

THE Taylor Internal Reflux Computer Control System consists of the addition of a simple analog computer to a fractionating column. It maintains optimum reflux flow by instantly compensating for climatic effects encountered in outdoor installations. This means:

1. Consistent product quality—no rerunning or blending.
2. Maximum utilization of existing installation.
3. Minimum consumption of steam, air and water.
4. Elimination of flooding—run to design capacity without loss of product.
5. Increased production with no process change. Adaptable to any column design and existing piping and instrumentation.

• • •

Here are Phillips Petroleum Company's answers to questions commonly asked about this system:

Are steam savings effected when using Internal Reflux Computer Controls?

"They minimize reflux adjustments necessary for day and night ambient temperature changes, thereby effecting steam savings. At the same time they contribute to the maintenance of overhead product specifications. A lower reflux ratio obviously saves steam".

Are increased product yields realized by use of computer-controls?

"While it is difficult to pin-point exact increases, we can say they permit continued tower operation at maximum load levels. Without reflux computer-controllers, column operation must be at a less efficient level to reduce hazard of flooding".

Does use of computer-controllers permit use of lower reflux-to-product ratio?

"Yes—particularly when operating to maintain product specifications, such as a minimum of 95% isopentane overhead product. Without computer-controllers it would be necessary to operate at 97% isopentane to insure a minimum 95% product".

Do computer-controllers help meet product specifications?

"Yes—they compensate and 'short-stop' transient column conditions resulting from minor temperature, pressure and feed composition changes. It is no longer necessary to have product samples analyzed in the laboratory to serve as a guide for the operator to make changes in external reflux flow rate".

Are plant operators pleased with the performance of computer-controllers?

"They are well pleased with the installations. They appreciate the smoother column operation and ease of meeting product specifications."

• • •

Ask your Taylor Field Engineer for full information about this system, developed and licensed by Phillips Petroleum Company, or write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Ontario.

MEAN ACCURACY FIRST

"In modern manufacturing, electrical control equipment is the very heart of mechanized and automatic operation. Because our plants have become so dependent on this equipment, the cost of 'down time' for any control failure is simply staggering. And, according to many manufacturing engineers, limit switches are the worst offenders, accounting for as much as 70% of all interruptions due to control failures."

Mr. J. S. Wilford, Editor
PRODUCTION Magazine

"At least 60% of the electrical failures causing downtime of the production machinery used in manufacturing home appliances at the Whirlpool Corporation can be traced to faulty limit switch operation. An analysis of the switch failures reveals the inability of limit switches to meet the requirements of high production equipment such as is widely used in our St. Joseph Division."

Mr. C. R. Burg, Maintenance Engineer,
Whirlpool Corporation

"75% of the electrical failures on our machines can be traced directly to limit switch malfunctions. This problem is particularly aggravating to us because we are responsible for the successful operation of our machines and their components on our customer's floor. We have spent a great deal of time engineering protective mounting schemes to compensate for the inability of today's limit switches to check the seepage of corrosive coolants and microscopic grit."

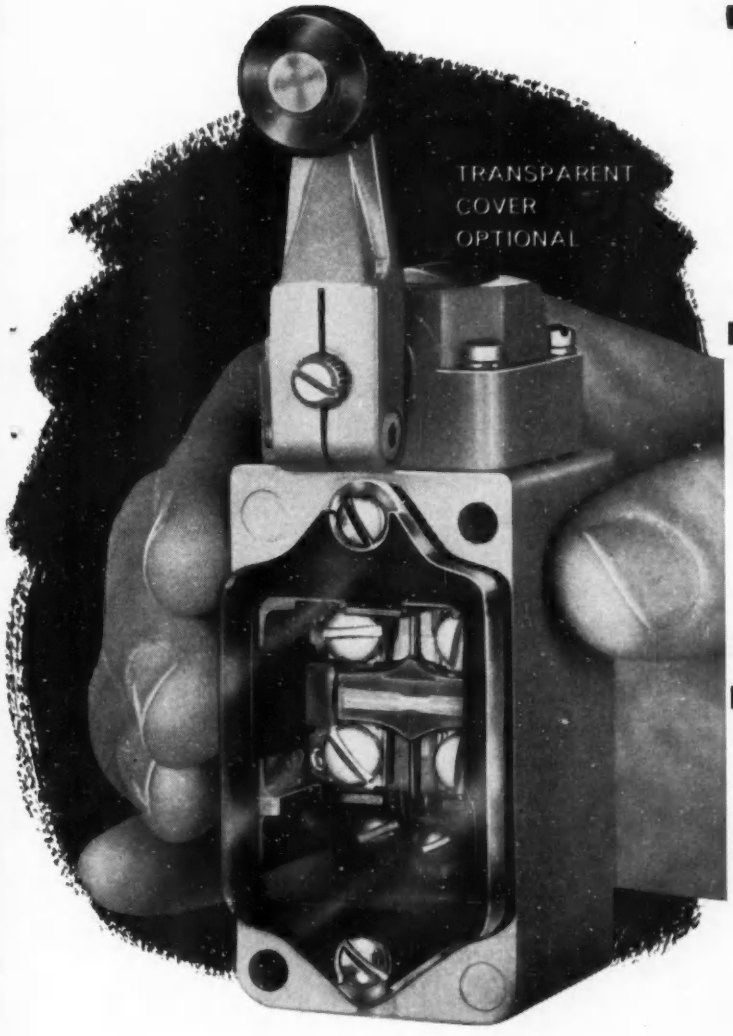
Mr. N. P. Bashor,
Director Electrical Division,
W. F. & John Barnes Company

Production's Enemy #1 MEETS ITS MASTER

Cutler-Hammer announces the *first*

- ***Tolerance Compensated***
- ***Contamination-proof***
- ***Visible Contact***

Extended Life Limit Switch



Tolerance Compensation

The new Cutler-Hammer Extended Life Limit Switch represents a startling break-through in high-precision manufacturing methods. Each sub-assembly is accurately calibrated so that in final assembly all plus and minus tolerances are precision balanced or compensated. Thus, tolerance compensation guarantees every C-H Extended Life Limit Switch will operate identically with precise repeat accuracy and ultra-long life. No binding . . . no sticking . . . no points of concentrated stress or wear.

Contamination-proof

New triple sealing positively checks seepage of all forms of oil, coolants, moisture, and abrasive grit. New cone-seal stops seepage through the operating shaft bearing. New vulcanized bellows-seal between the operating head and body eliminate the troublesome "O-ring" seal . . . won't wear . . . never needs attention. New cover seal seats on a raised lip . . . repeated opening and closing of the cover won't destroy the seal. Total-submersion life tests prove the new C-H Extended Life Limit Switch to be contamination-proof . . . suitable for even dry circuit applications.

Visible Contacts

Another Cutler-Hammer *first* . . . this new Cutler-Hammer Limit Switch provides completely enclosed but *visible* single pole double throw switch contacts. During installation, one glance shows which contacts are open and which are closed . . . no chance for wiring errors. During operations, one glance proves whether the switch is set and operating correctly. Positive visible inspection cuts maintenance costs too.

Compare these features, too!

- **One basic model is readily adapted to all desired forms of lever or plunger actuation . . . for either momentary or maintained contacts . . . for either surface or cavity mounting.**
- **Unsurpassed flexibility: 90° orientation of the operating head. 360° rotation of lever arm with a locking device that holds the adjustment. Lever operators provide clockwise, counter-clockwise, and clockwise-counter-clockwise actuation . . . easy to set on the job without disassembling the switch.**
- **Precise actuation . . . 10° pretravel—40° overtravel or 5° pretravel—45° overtravel.**
- **Visible, saddle-clamp terminals . . . no loose fibre flash-over barriers.**
- **Unitized switch mechanisms are interchangeable . . . speeds replacements when overload or short circuit damage occurs.**
- **Meets all JIC and NMTBA requirements. Easy, complete interchangeability with any widely used limit switch.**

The new Cutler-Hammer Extended Life Limit Switch installs easier, works better, and lasts longer than any of the "oil-tight" limit switches now in use. Exhaustive tests, including total-submersion life tests, confirm this fact! But don't take our word for it. Try it . . . Test it . . . Compare it. The new Cutler-Hammer Extended Life Limit Switch is completely interchangeable with any widely used limit switch. Replace your *most* troublesome limit switch installation with this new tolerance compensated, contamination-proof, visible contact Cutler-Hammer Limit Switch; and it will work better, last longer than any other you have ever used. This is the answer to your limit switch problems.

For descriptive data write for Publication **ED143-E297.** Cutler-Hammer, Inc., Milwaukee 1, Wisconsin.

CONTROL

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wis. • *Division:* **Airborne Instruments Laboratory.** • *Subsidiary:* **Cutler-Hammer International, C. A.**

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.

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POWER SUPPLIES...

Here's reliability . . . Since their introduction, over 18 ~~months~~ 30 months ago, not one Regatran has lost a series transistor due to short circuits or overloading.

- transistorized
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- super-regulated
- overload protected
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- High-speed regulation
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MODEL T036-5M

NOW . . . higher current REGATRANS

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- front panel calibration
- any grounding arrangement
- small size, light weight

WIDE RANGE MODELS

MODEL NUMBER	D-C OUTPUT	
	VOLTS	AMPS
T060-15	0-60	0-15
T036-30	0-35	0-30
T032-30	0-32	0-30
T014-30	0-14	0-30
T07-30	0-7	0-30

Brief Specifications (all models)

REGULATION, LINE OR LOAD: 0.03% or 0.01 V (0.01% or 0.003 V available).

RIPPLE: Less than 1 millivolt rms.

CIRCUIT PROTECTION: (1) electronic circuit breaker plus (2) electromagnetic circuit breaker plus (3) input line fused.

NARROW RANGE MODELS ALSO AVAILABLE

REQUEST BULLETIN 721A (Revised) FOR COMPLETE SPECIFICATIONS

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® Registered U. S. Patent Office. Patents Issued and Pending.

Newsbreaks In Control

● Ultrasonic Flowmeter Boasts Linear Characteristics

London—British Scientific Instrument Research Association has developed an ultrasonic flowmeter with unusually good linear characteristics. Over a 25 to 1 range, the device demonstrates linearity of better than one percent. Method of operation: two crystal transducers, mounted outside a 12-in. length measuring section of pipe, alternately transmit and receive an ultrasonic wave to measure upstream and downstream velocities. Velocity difference is abstracted in the form of pulses which are averaged by a moving coil meter to indicate flowrate directly.

● AIEE Hears Computing Control Developments

New York—Impact of computing-control was surprisingly sharp at annual meeting of American Institute of Electrical Engineering. Three separate sessions were devoted to the subject. New developments announced: Westinghouse Electric Corp. has sold its new general purpose digital computer for process control to a steel company to control a hot mill; Daystrom Systems has sold an information system to a steel company, Great Lakes Steel Corp., to control a hot mill; Librascope, div. of General Precision, Inc., has a new transistorized control computer, the Libratrol-1000.

● Magnetic Drum for Steel Mill

Lackawanna, N. Y.—Bethlehem Steel Co.'s new 12,000-hp slabbing mill will store its library of rolling schedules in a magnetic drum, the first such control system in the steel industry. The drum will replace punched cards which are not as easy to handle in a heavy industrial environment.

● Chromatographs Star at ISA Winter Conference

Houston—The gas chromatograph was the star of the ISA's first winter session. One instrument specialist, T. C. Wherry, Phillips Petroleum, predicted that 600 to 1,000 gas chromatographs will go on line in 1960, and at least 10 percent of them will be in closed-loop systems. Typical of such systems was one displayed by Consolidated Electrodynamics Corp. (perfected with Taylor Instruments Cos.) to sell at about $7,000.

● Heard at Houston

Prices of industrial computers for control will drop at least 10 to 15 percent over the next two years because of economies in design and reduction of component prices. Major reductions will stem from halving of transistor prices and a reduction in magnetic drum costs. . . . *RCA will soon offer* a magnetic drum process control computer to supplement its RCA 110 core memory process machine . . . *First application* of CEC-Taylor's closed-loop chromatograph was at Reef Corp.'s natural gasoline plant in Big Springs, Tex.

IRE MEETING:
Previewing the Control Highlights

Electronic control and instrumentation, long well established in the aerospace and missile industry, are winning increased acceptance in machinery, machine tool, and chemical processing industries. Proof of this greater acceptance is the large number of sessions scheduled at the national IRE meeting (March 21 to 24) in control or in areas impinging on specialized interests of control engineers. In the chart (right) CONTROL ENGINEERING has picked out the key sessions for control engineers. Shown in boldface type are sessions of broad interest to control engineers; shown in regular type are those sessions of specialized interest.

• **Monday's offerings**—During Monday afternoon, the IRE will offer five different sessions (held concurrently) of interest to control engineers. Probably the most important is the one on Control Theory, to be held in the Starlight Room of the Waldorf Astoria Hotel. Session organizer John Ward, Massachusetts Institute of Technology, told CtE that the object of this session was to push back the frontiers of theory. Papers to be presented.

Incremental Phase Plane Analysis of Nonlinear Sampled Systems
by J. A. Aseltine and R. S. Nesbit
On the Existence and Uniqueness of the Optimal Multivariable Systems Synthesis
by M. D. Mesarovic
On Optimal and Suboptimal Policies in the Choice of Control Forces for Final-Value Systems
by M. Aoki
A Study of Asynchronously Excited Oscillations in Nonlinear Control Systems
by O. I. Elgerd
On the Optimum Synthesis of Sampled Data Multiple Filters with Random and Nonrandom Inputs
by H. C. Hsieh and C. T. Leondes

Of these, the broadest appears to be the Aseltine and Nesbit paper. It will discuss a technique for analyzing nonlinear sampled data systems which are being studied for possible applications in chemical processes, missiles, and space vehicles. The method described is analogous to the phase-plane method for continuous systems. Hsieh and Leondes will discuss how to synthesize an optimum multipole filter.

Also on Monday afternoon, the transistorized nuclear instrumentation session will hear reports on devices that range from radiation monitoring equipment to the controls of the new Brookhaven Alternating Gradient Synchrotron. The meeting on rf interference will be concerned heavily with the simulation of tests and signal noise of electronic equipments, an activity encouraged by the U.S. Army's plans to carry out interference testing at Fort Huachuca (CtE, Aug. '59, p. 25). In the session on aerospace subsystems, a new measuring device, an ion altimeter, will be described; a new measuring technique, astro doppler velocity, will be discussed; and a new method of display will be reported, one which generates an artificial electronic view for the pilot of the vehicle. In the electronic devices meeting, a number of devices used by control engineers will be discussed; power transistors, optical encoders, and an NPN fusion alloy transistor are the headliners.

• **On Tuesday**—The big control meeting on Tuesday morning will be on control applications. MIT's John Ward also organized this session. The papers:

Decoupling Techniques in Multiloop Control Systems
by R. H. Loomis
Optimum Compensation of a Position Servo with a Magnetic Clutch Actuator
by R. J. Hruby
Synthesis of a Self Adaptive Autopilot for a Large Elastic Booster
by G. W. Smith
Design of Optimum Beam Flexural Damping in a Missile by Application of Root-Locus Techniques
by R. J. Hruby
Flywheel Control of Space Vehicles
by J. E. Vaeth

The papers of this session are oriented heavily towards the missile and aerospace field.

Other interesting Tuesday morning sessions include the ones on engineering management, varied views of medical electronics, and the broadening horizon for devices. In the latter, visitors will hear state-of-the-art reports on four of the newest practical devices to be introduced in recent years:

Masers
by J. W. Meyer
Variable Reactance Devices
by B. Salzberg
Tunnel Diodes
H. S. Sommers, Jr.
Functional Devices
by W. A. Adcock

Adcock's paper will report some of the work done in the new field of molecular electronics (see page 35 for a report by another manufacturer in this field).

On Tuesday afternoon the session on industrial electronic instrumentation will investigate the application of electronics in still newer fields, from supermarket automation to agriculture. And the session on radar and coding theory is aimed at those with data transmission and conversion problems.

• **Wednesday's menu**—Many of the IRE sessions on Wednesday are concerned with communications equipments and systems. But four meetings will interest the control field: Detection Theory and Applications to Physics, Space Telemetry, Aspects of Component Reliability, and Components. In the last session, H. L. Dudley (Melpar) will present an especially interesting paper, entitled "The Reliable Application of Electronic Component Parts". After surveying 18,000 electronic equipments constructed of 5,000,000 electronic components, the author found that 5 percent of the parts were responsible for all failures—the result of misapplication. With such data as a base, he describes pitfalls in

CONTROL ENGINEER'S GUIDE TO THE 1960 IRE MEETING

	WALDORF-ASTORIA HOTEL			NEW YORK COLISEUM	
Monday, March 21 **2:30-5:00 p.m.**	STARLIGHT ROOF: **Control Theory**	ASTOR GALLERY: Transistorized Nuclear Instrumentation	SERT ROOM: R.F. Interference	FARADAY HALL: Advances in Aerospace Subsystems	MORSE HALL: Electronic Devices
Tuesday, March 22 **10:00 a.m.-12:30 p.m.**	STARLIGHT ROOF: **Control Applications**	GRAND BALLROOM: Engineering Management		FARADAY HALL: Varied Views of Medical Electronics	MORSE HALL: **Broadening Device Horizons**
2:30-5:00 p.m.	STARLIGHT ROOF: Radar and Coding Theory	ASTOR GALLERY: **Industrial Electronic Instrumentation**			
Wednesday, March 23 **10:00 a.m.-12:30 p.m.**	STARLIGHT ROOF: Detection Theory and Applications to Physics	SERT ROOM: Space Telemetry		MARCONI HALL: Aspects of Component Reliability	
2:30-5:00 p.m.	JADE ROOM: **Component Parts**				
Thursday, March 24 **10:00 a.m.-12:30 p.m.**	STARLIGHT ROOF: **Adaptive Networks**	EMPIRE ROOM: Satellite Communications		FARADAY HALL: Human Factors in Electronics	MORSE HALL: **Magnetic Recording**
2:30 p.m.-5:00 p.m.	STARLIGHT ROOF: **Electronic Computers**	ASTOR GALLERY: Symposium: Decade of Progress in Network Theory	SERT ROOM: Checkout Instrumentation and Circuitry	MORSE HALL: Waveform Analysis and Random Vibrations	

designing equipment and discusses how the circuit designer should check a breadboard to assure a reliable design.

• **Finals Thursday**—Three key sessions are to be offered on Thursday. The first is on adaptive networks; much of this material falls in the developmental stage. The papers range from "Pattern Recognition with an Adaptive Network" to reports on the Perceptron, the device being built at the Cornell Aeronautical Laboratory under Office of Naval Research sponsorship to imitate the association performance of the human brain. The session on magnetic recording is of interest to anybody who has to work with magnetic tape equipment. The papers:

The Effects of Track Width in Magnetic Recording
by D. F. Eldridge and A. Baaba
Erased Carrier Recording
by W. J. Murphy
Reliability and Drop-out Studies for Long Playing Loops
by A. Wilson
Digital Magnetic Recording with High Density Using Double Transition Method
by A. Gabor
Automatic Error Detection Equipment of Digital Tape Recorders
by G. J. Slusarchyk, T. D. Radway, and P. Heller

Still another key session is on computers, scheduled for Thursday afternoon. The papers show broad coverage from a gas flow application to design features of the giant LARC computer. The papers:

On-line Solid State Analog Computer for Automatic Gas Flow Compensation
by F. P. Simmons
Very High Density Digital Magnetic Recording
by D. E. Killen
A Tunnel Diode Tenth Miscrosecond Memory
by M. M. Kaufman
Automatic System and Logical Design Techniques Used on the RW-33
by T. A. Connolly
Logical Design Features of the LARC System
by W. F. Schmitt and L. F. Harrison

Another report of interest to computer specialists will be presented at the session on satellite communications. M. P. Falls and T. A. Christie, Jr., will present a paper describing "A Digital Data Handling System for Real-Time Computation on the Atlantic Missile Range". Space exploration, particularly the man-in-space program, has sharpened interest in real-time computing capabilities.

Other Thursday sessions of interest to the control-field: Human Factors in Electronics, Waveform Analysis and Random Vibration, Checkout Instrumentation and Circuitry, and a symposium on A Decade of Progress in Network Theory.

During the four-day technical conclave, the IRE will be running nine concurrent sessions, starting Monday afternoon and continuing every morning and afternoon.

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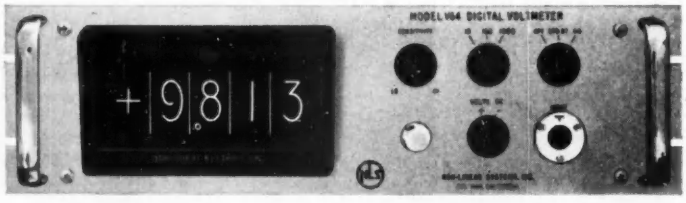

FOR THE FIRST TIME you can have the accuracy, speed and reliability of an NLS digital voltmeter with full four-digit resolution . . . for the price of a quality pointer meter. That's the dramatic story of the new NLS V64! Only NLS high-volume production techniques make it possible. Use the low-cost, versatile V64 for a wide range of measuring jobs. See the V64 in action . . . contact NLS today!

BRIEF SPECIFICATIONS: Accuracy ± (.02% of reading plus 1 digit) . . . full 4-digit resolution . . . measures DC voltages from one millivolt to 500 volts in steps of ±9.999/99.99/500.0 . . . one package design (5¼" high, 15¼" deep for 19" rack) . . . plug-in accessories permit measuring AC or low-level DC voltages . . . available from stock for immediate delivery.

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NLS — The Digital Voltmeter That Works . . . And Works . . . and Works!

Scented Movies Are Broadway's Newest Hit

And there's an interesting control system behind them. A metallic tape on the film cues a timing system to insure that aromas are sensed at the right time.

NEW YORK—The dimension of scent has been injected into motion pictures by a new process called AromaRama. As scenes of a new movie, "Behind the Great Wall", unfold, the audience can smell the scene as well as see the action and hear the dialogue and background music. In the technique premiered at New York's DeMille Theater, scent is injected into the theater's air conditioning system, circulated throughout the theater, then removed by an electrostatic air cleaner. AromaRama is the creation of New York impresario Charles Weiss.

A strip of metal tape cemented to the film cues the release of the smell. As the metal strip passes under a specially designed trigger on the projection machine, an electrical pulse is sent to a timing control which positions the proper can of scent in front of the intake of the air system, sprays the scent contained in an Aerosol packed can, and times the length of spray. The control system was built by Industrial Timer Corp.; the special trigger device was developed by Camera Equipment Co.

In "Behind the Great Wall", 33 scents are sprayed into the audience, odors ranging from the gamy smell of a tiger to the appetizing aroma of oranges. Cans containing the scents (whose compositions are a closely guarded secret) are arranged on a turntable located high above the audience in the theater's fan room. For the initial equipment, Industrial Timer built a turntable that will handle 70 cans of spray.

Sole requirement for the installation of AromaRama in any theater: it must be possible to inject the scents into the air conditioning system. The control system has been designed so that it can accommodate the different time required for the odors to move from the intake to the audience in different theaters.

Here's what happens behind the scenes of AromaRama. When the turntable is set up, cans of scent are placed in it in the order in which they will be used during the movie. If one particular odor is used more than once, there will be more than one can of that scent in the turntable.

At the start of the performance, an operator in the projection booth "homes" the turntable (which is in the fan room) by pushing a button, moving the can of scent with the first odor to a standby position. When the first metal cue strip on the film passes under the trigger it sends an electric pulse to start a 60-sec TDAF timer (called the cue timer). The start of this timer also closes a relay to move

Turntable in fan room at DeMille Theater is duplicated (just visible at top of photo) because theater is too large for single injection of scent. One control system operates both at once.

Chief Projectionist Rex Wilson holds the leader of the first AromaRama film. Metallic cue strip is visible on left edge. Behind strip is timing control.

the turntable so that the first can of scent moves from the standby position to the "ready" position under a solenoid operated plunger. The setting on the first timer depends on the size of the theater and how long it takes the aroma to reach the audience; it is different for each theater.

At the end of the cue time, a pulse actuates one of two other timers, a spray timer which determines the length of a standard spray, or an alternate timer which holds the spray for some other preset time. At the same time, a relay is closed actuating the solenoid which causes a plunger to depress the spray button on the can of scent.

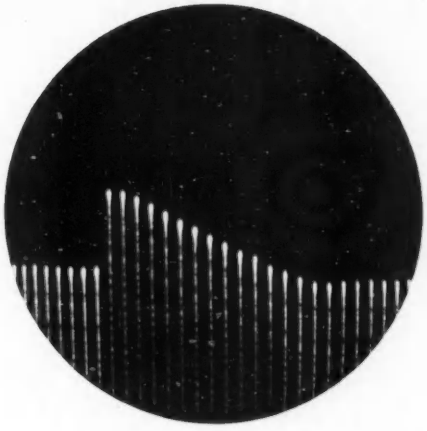
Which timer gets the impulse depends on the arrangement of a pegboard located in the center of a turntable. When the demonstration is set up, the operator chooses (based on the script) one condition for each scent: a standard spray (he does nothing to the pegboard), an alternate spray (he places a spool with two different diameters on a peg with the large diameter at the bottom), a repeat of the standard spray (he places the two-diameter peg with the large diameter on top), or a repeat of the alternate spray (by placing a large diameter spool on the peg). This flexibility allows a scent to be sprayed for almost any length of time desired.

When the spraying cycle is completed, a pulse from the timer closes still another relay to move the turntable so that the can with the second odor is in the standby position. The process then repeats for each odor.

To date, AromaRama has been presented in New York and Los Angeles. But Industrial Timer Corp. has orders for twelve more theater systems. The company thinks that there may be even a bigger market than just theaters for the system. If aromas catch on with audiences, Industrial Timer thinks that food stores might adopt it to remind shoppers with an aromatic hint of items on sale.

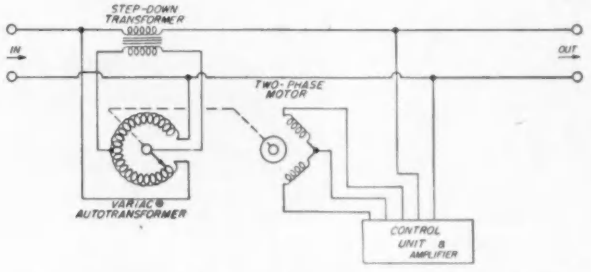
SERVO-OPERATED
Line-Voltage Regulator

50-Ampere, 6-KVA Capacity in a One Cubic-Foot Package



Oscillogram shows peaks of 60-cycle line voltage with sudden 2% change, and subsequent correction by regulator. Change is corrected in 12 cycles (0.2 sec.).

★ Handles up to 500 Amperes on Short-Period Overload
★ Holds Line Voltage Constant to ±0.25%
★ NO Waveform Distortion
★ NO Power Factor Restrictions
★ NO Relays to Cause Transient Pulses or Chattering
★ NO Dead Zones
★ Can Be Connected to Handle 10% or 20% Line-Voltage Variations
★ Output Voltage Can be Varied ±10% from Nominal Voltage



How it works— Any deviation from normal line voltage is sensed by the control unit. The resulting error voltage, amplified by a two-stage balanced amplifier, changes the firing angle of a push-pull thyratron circuit which in turn controls a low-inertia, two-phase servo motor. The motor adjusts a Variac® autotransformer which delivers a correction to the input line voltage through a buck-or-boost transformer.

The control-circuit thyratrons operate continuously and produce two, equal, in-phase motor voltages. Any line-voltage variation causes a proportionate change in phase angle between these two voltages. This change of phase produces a corresponding motor torque, causing correction to take place. Thus, smooth, truly proportional control is achieved, with consequent better accuracy, faster response, and less overshoot (see oscillogram) than is found in regulators using on-off methods.

Militarized Model
with Separate Control and Regulator Units.
Meets requirements of MIL-E-4158B and MIL-E-16400B
for 115-volt, 45-55- and 55-65-cycle lines, **Type 1570-ALS15** . . **$670**
for 230-volt, 45-55- and 55-65-cycle lines, **Type 1570-AHS15** . . **$690**

Standard Model
Available in table, rack, or wall models
for 115-volt, 60-cycle lines, **Type 1570-AL** **$490**
for 230-volt, 60-cycle lines, **Type 1570-AH** **$510**
50-cycle models also available

Two other models available — *A three-phase militarized model for regulation of balanced systems.*
A regulator for control of 150- to 500-cycle lines (requires 50- or 60-cycle power).

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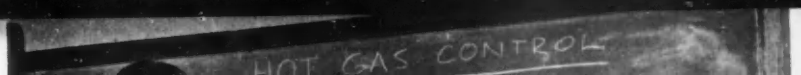
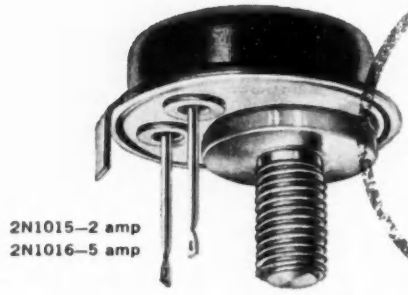
CIRCLE 27 ON READER SERVICE CARD



INCREASED RELIABILITY PLUS HIGHER OPERATING TEMPERATURES with Westinghouse Silicon POWER Transistors*

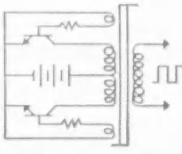


2N1015—2 amp
2N1016—5 amp

PROVED PERFORMANCE IN
- Inverters
- Series Regulators
- A.C. Amplifiers

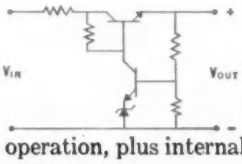
Westinghouse 2N1015 and 2N1016 Silicon Power Transistors offer positive, *proved* benefits to designers of inverters, series regulators, and A.C. Amplifiers.

INVERTERS...



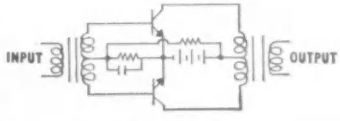
Extremely low saturation resistance (typical .3 ohms) minimizes power losses in the transistor. High temperature (150°C T_j max.) operation permits compact inverter designs for missiles, aircraft, and other military equipment.

SERIES REGULATORS



High voltage ratings and high temperature operation, plus internal power dissipation of 150 watts made possible by low thermal resistance of .7°C/watt make the 2N1015 and 2N1016 an ideal choice for constant voltage and constant current regulators.

A.C. AMPLIFIERS...

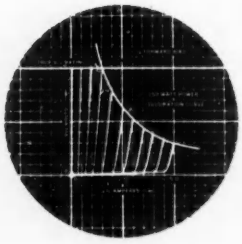


Perfect choice for high power audio and A.C. Amplifier applications, thanks to their high power dissipation capabilities and common emitter frequency response to 20KC.

PLUS TRUE VOLTAGE RATINGS...

guaranteed by 100% power testing. Means you can operate these transistors continuously at the V_{CE} listed for each rating without the risk of transistor failure.

Production quantities of Westinghouse Silicon Power Transistors are available in 2 and 5 ampere collector ratings. Both are available in 30, 60, 100, 150, and 200 volt ratings for immediate applications. Contact your local Westinghouse Apparatus Sales Office, or write directly to Westinghouse Electric Corp., Semiconductor Department, Youngwood, Penna.



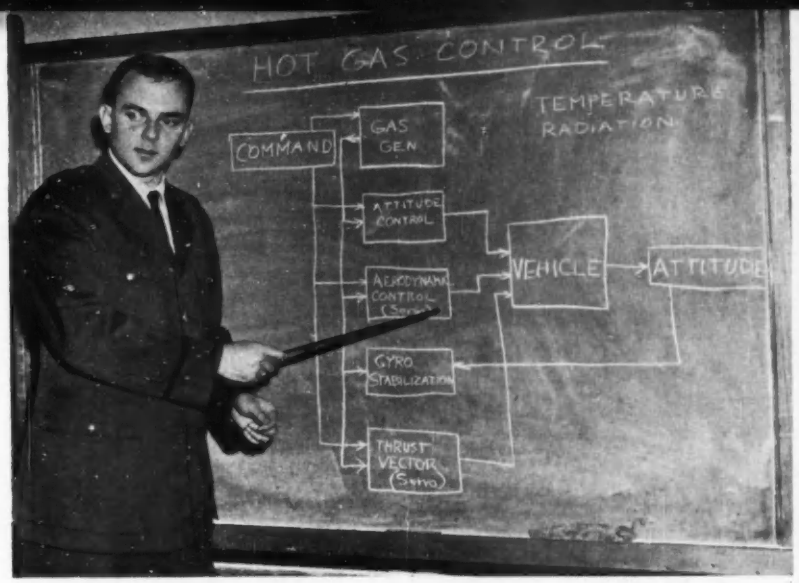
*Designed to meet or exceed military specifications and currently being used in many military, industrial, and commercial applications.

Type	V_{CE}*	B (min)	R_B (max)	I_C A (max)	T_j max. operating	Thermal drop to case (max)
2N1015 2N1015A 2N1015B 2N1015C 2N1015D	30 60 100 150 200	10 @ I_C=2 amp	.75 ohms @ I_C=2 amp I_B=300 ma	7.5	150°C	.7°C/W
2N1016 2N1016A 2N1016B 2N1016C 2N1016D	30 60 100 150 200	10 @ I_C=5 amp	.50 ohms @ I_C=5 amp I_B=750 ma	7.5	150°C	.7°C/W

*TRUE voltage rating (The transistors can be operated continuously at the V_{CE} listed for each rating.)

YOU CAN BE SURE...IF IT'S Westinghouse

Fundamental control problems that started with aircraft have spread into missiles and space. CtE visits Wright-Patterson's Flight Control Laboratory to see its new look.



Lt. R. L. Lankford, project officer on the hot gas control system outlines the generalized system.

Wright-Patterson Shifts Gears: Aircraft Control Spills Over Into Space

DAYTON—Cancellations and cutbacks in military aircraft development have cooled the pilots at Wright-Patterson Air Force Base these days. But in the laboratories Air Force engineers and scientists continue to study problems that started with the airplane, now spill over into missiles and space vehicles. Last month, CONTROL ENGINEERING visited Wright Air Development Division Flight Control Laboratory, found interest centering on three burgeoning projects:

- ▶ adaptive control systems
- ▶ hot gas systems
- ▶ mechanical control

In addition, the Laboratory is examining a new approach to cockpit display, one intended for manned space vehicles as well as aircraft; integrated cockpit instrumentation; an advanced flight data system which will combine the best state of the art in inertial systems with the best in flight control; and an automatic landing system still too new to even talk about.

In an organization chart and listing of project areas, you can see how the Flight Control Lab has shifted its sights to missile and space projects. Activity falls in three main areas: 1) basic stabilization of a flight vehicle (aircraft, missile, or space ship); 2) control of the flight path (as opposed to guidance which determines what the flight path should be); and 3) energy management. Under the command of Col. F. B. Carlson, FCL now has about 180 people hard at work on fundamental control problems. The Laboratory will distribute almost $10 million for out-of-house research on its projects this year.

• **Classical stability**—In the aeromechanics branch, which is interested in classical stability and control, a key project is the study of the effect of high temperature and elasticity on stability—a major concern in the control of missile and space vehicles.

Meanwhile, the design engineering group is attempting to determine what information a pilot needs in each phase of flight—in the atmosphere or out. Lear, Inc., has been awarded a research grant to help spell out these requirements.

• **Adaptive progress**—FCL is generally credited with sparking interest and progress in adaptive control systems (controls which change their characteristics with changes in environment). At a WADD symposium last year (CtE, Mar. '59, p. 22), engineers from all over the U.S. reported on current projects in adaptive systems. Last month, Lt. Philip Gregory, who replaced Capt. Raymond Rath as adaptive systems project officer, told CtE what has been happening in FCL's adaptive projects since the symposium. Some progress:

▶ Three aircraft with adaptive systems or parts of systems are now being flight tested.

▶ A modified version of the Minneapolis-Honeywell "bang-bang" system has been flight tested satisfactorily in an F-101 fighter. In a recent test the pilot could detect no limit cycle (a continuous oscillation) of the system, something which designers had feared.

▶ The MIT system, mechanized by Lear, Inc., is being flight tested in an F-101.

▶ The cross correlator which measures impulse response, the criterion in the Aeroneutronic system, is being flight tested to determine if impulse response can be measured well enough to serve as a criterion. The immediate future of the Aeroneutronic system hangs on this test. If it is successful, the complete system will be flight tested later this year.

▶ Minneapolis-Honeywell has a contract to design a control system for an advanced space vehicle, integrating aerodynamic and reaction controls. Designed primarily for an orbital vehicle like the Air Force's

WHAT'S NEW

Dyna-Soar, the system will be flight tested in the X-15 research vehicle.

In a space vehicle, says Project Officer Gregory, adaptive controls are primarily needed during exit from and reentry into the atmosphere, because at these times parameters—such as dynamic pressures or damping which varies from zero to overdamped—change rapidly over a wide range.

Gregory also reports an awakened interest in adaptive systems by missile makers. At least one project is attempting to apply adaptive controls to compensate for the elasticity of the missile structure, which oscillates appreciably as the missile takes off through the atmosphere. Currently missile makers attempt to filter out troublesome oscillations, but it takes tremendous amounts of computation to determine where to put the filters.

Much of FCL's future activity in adaptive systems will be aimed at uncovering new areas of application and studying the theoretical aspects and mathematics of such controls.

• **Hot gas work**—The hot gas servo as a component has been in the missile spotlight for many months now. Although there is some performance data available, nobody has attempted to put together a complete hot gas control system. FCL has now proposed such a system, has received 23 proposals, involving 65 companies, to build it.

FCL's control calls for taking a hot gas from a source to operate servos to move aerodynamic surfaces and to swivel control rockets. In addition, the gas will serve as the medium in reaction controls. And the hot gas will drive rate gyros for damping and perform some pneumatic computation. Signal pickoffs and transmission will be pneumatic.

But there are some complex problems to be solved before the hot gas system will be usable. FCL Chief of Operations G. L. Yingling points out four tough areas. First is the source itself. What kind of gas generator to use? How to generate gas in the proper quantities at the proper time?

A second problem is specifying materials for components that operate at such high temperatures. Items like seals, valving, and lubrication pose particularly knotty problems.

The dynamics of hot gases have to be studied. Since the gases are compressible, they will act like a spring, thus limiting the frequency at which the system can operate.

And finally, servo dynamics will have to be studied. Such questions

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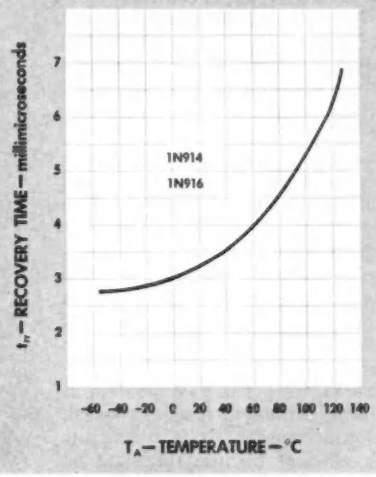
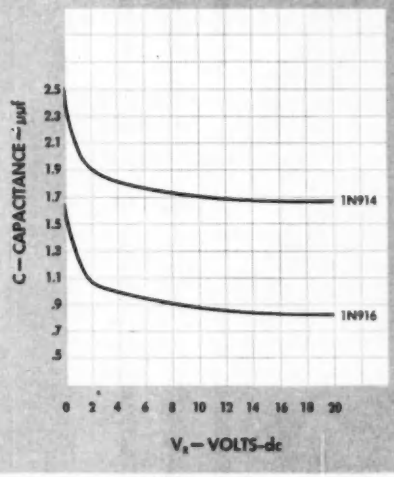
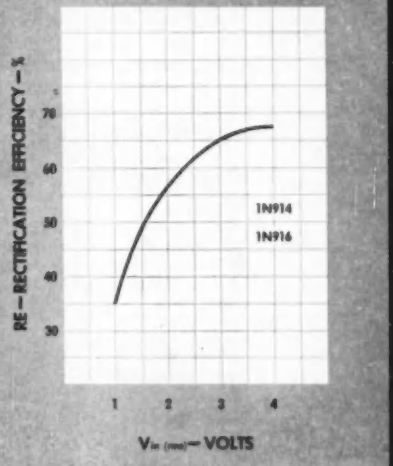


TYPICAL CAPACITANCE VS VOLTAGE



TYPICAL RECTIFICATION EFFICIENCY AT 100 MEGACYCLES VS VOLTAGE



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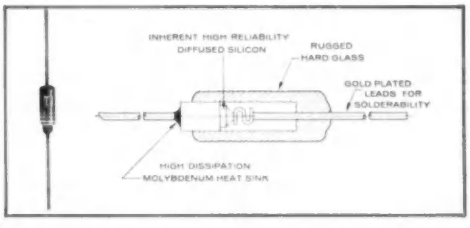

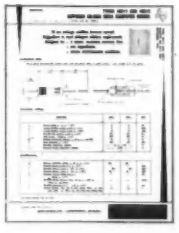

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Put them to work NOW in your high-speed computer circuitry for missiles and space vehicles. They are ready in production quantities through your nearest TI sales office, or in 1-999 quantities off-the-shelf at factory prices from your authorized TI distributor.

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CIRCLE 31 ON READER SERVICE CARD

WHAT'S NEW

as what kind of feedback to use and how to improve servo dynamics will have to be answered.

• **Mechanical controls** – A promising mechanical system proposed by Curtiss-Wright is now in Phase II of development; Phase I, feasibility, has been completed. The control, says H. W. Basham, of FCL's Control Equipment Branch, can be used in missiles or in aircraft for landing gears, speed brakes, or flight control.

C-W is currently building four complete systems: one for simulation studies, one to be flight tested this summer, and two for backup. C-W has chosen flight control to demonstrate its concept.

To exert control, the pilot moves his control stick in a conventional manner, but the movement causes a spring clutch in the control servo to engage gears that are rotating continuously. Rotational motion is then transmitted to the actuator which is an epicyclic gear train. In the first design this specially designed device combines wing hinge and actuator.

Basham feels the C-W system is promising because it is a high speed, low torque system. It is potentially highly efficient because there are no transformations of energy; control starts and ends with rotary motion. He cites these other potential advantages of such a system:

▶ high temperature capability—the control is all metal, has no fluids or seals. It can operate at the same temperature as the airframe. And it can operate at high temperatures—500 to 1,000 deg F—for long periods: hundreds or thousands of hours.

▶ lightweight—initial studies predict a 25 to 40 percent weight saving, primarily because of reduced redundancy. There is a big saving from combining the hinge and actuator.

▶ radiation resistant—the control has no fluids or electronics which might be affected by nuclear radiation.

▶ accurate control—the dead band and free play in the mechanical system still permit an accuracy of control comparable with hydraulic systems.

▶ high efficiency—off-on type of system. When there is no call for motion no input power is required.

▶ high surface stiffness—because of its dense design, the system tends to resist flutter. Loads are distributed down the length of the surface.

The prototype flying mechanical system will be incorporated by North American Aviation in an F-100 aircraft to control ailerons.

—Lewis H. Young

this is the Brush Mark II... anyone can plug it in put it in writing anywhere

There is no direct writing recorder on the market that approaches the compact Mark II in sheer usefulness. It is a completely integrated engineering tool that can be operated by anyone . . . in the shop or in the field . . . for countless research or design requirements. Every function necessary for uniform, crisp, easily reproduced readouts is "built-in". The Mark II gives you two analog channels plus two event markers; 4 chart speeds; DC to 100 cps response with 40 mm amplitude; 10 mv/mm sensitivity; high input impedance. Immediate shipment from stock. Call, write or wire for complete details.

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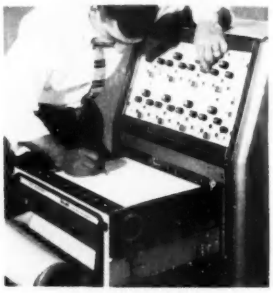
for direct writing recording systems no one is as qualified as Brush



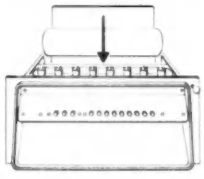
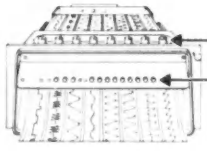
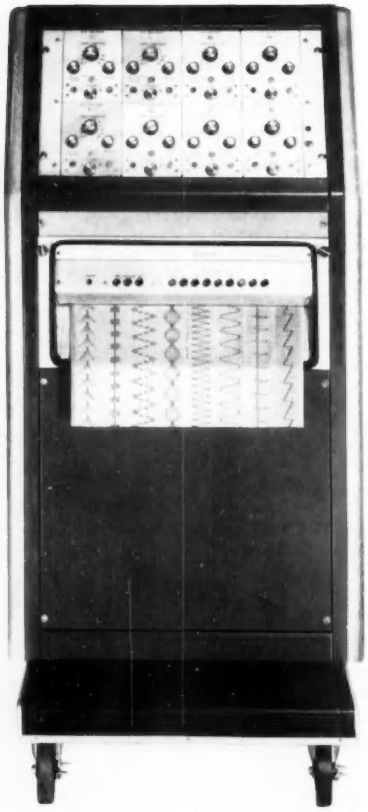


Chart paper loads from top



Trace contrast control

Simple pushbutton speed selection



Why? Simply because Brush recording systems such as this 6-8 channel unit incorporate all of the known refinements in the art of recording by direct writing. No comparable system in existence today is as compact . . . as simplified . . . as reliable . . . as versatile. Note slide-mounted oscillograph and interchangeable "plug-in" signal conditioners that provide four vital functions in addition to amplification: high input impedance, zero suppression, attenuation and calibration.

Instantaneous rectilinear presentation gives clear, uniform and reproducible traces for precise readout of telemetry, computer, ground control and other data gathering operations. Further, this functionally designed system has a "pull-out" horizontal writing table for convenient annotation and reading . . . without turning off the recorder! Check these and many other advanced features for yourself and you'll see why *no one* is as qualified as Brush. Call, write or wire for complete details.

brush INSTRUMENTS

DIVISION OF

37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

Molecular Electronics:

A Concept with Startling Implications

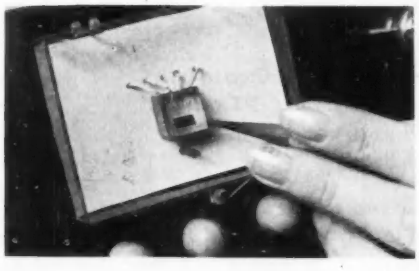
An electronic control system made from a single piece of semiconductor material? That is the implication of a new approach to designing electronic equipment. Based on designing functions, the new approach obsoletes traditional circuit concepts.

"Let's face it, gentlemen, this is the beginning of the end of the conventional electronic components business." The speaker was Col. W. S. Heavner, chief of electronic technology laboratory of the Air Force's Wright Air Development Center (for more news about WADC see page 29). What prompted so astonishing a statement was the demonstration of 20 startlingly new electronic equipments built by the Westinghouse Electric Corp., under WADC sponsorship—devices that included a combination photon detector and power amplifier, a 5-watt directly cascaded audio amplifier, a two-stage video amplifier, flip-flops, multivibrators (bistable, monostable, and astable), an OR logic unit, an analog to digital converter, and a variable potentiometer—all consisting of a single, small piece of semiconductor material (and leads).

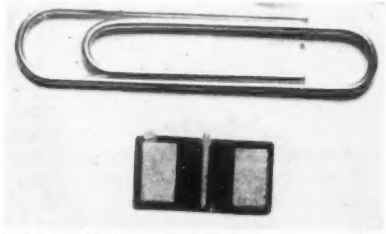
Dr. S. W. Herwald, Westinghouse's vice-president for research, explained what was done. Device designers started out by determining what function they wished to accomplish (amplification, switching, detection, etc.), then designed a device to do this by creating, modifying, and processing a semiconductor material so it can accomplish its task through solid state phenomena. Such phenomena include Seebeek generation, Peltier cooling, and Hall effect multiplication. What actually happens in a molecular electronic device, said Herwald, is that the electrons are directed (speeded up, multiplied, delayed, etc.) to accomplish the desired function. There's no consideration of resistance, capacitance, or inductance.

Formulating the proper material takes a knowledge of the crystalline structure of materials, electron spins, and field theory. A topologist then determines the structure of the block. A

MOLECULAR DEVICES



OR SWITCH.
Pencil points to switch, encapsulated in plastic block.



FREE RUNNING MULTIVIBRATOR.
Paper clip indicates size of actual device.

LIGHT TELEMETRY SUBSYSTEM.
Detects light and delivers output whose frequency is a measure of light intensity.

WHAT'S NEW

Westinghouse scientist is currently writing a book on design technique.

Characteristics of the molecular electronic device are an inherent part of the material, Dr. Herwald told a press conference. When one of the scientists was preparing the combination detector and power amplifier, he dropped a hammer on the single piece of semiconductor, shattering it. He found that each of the small pieces exhibited the capability of detection and amplification.

• **How far off?**—What is the time schedule for such startling types of equipment? Both Herwald and Heavner feel that simple one-piece electronic systems will appear in three to five years. In 1960 Westinghouse hopes to build a one-piece radio receiver for the Air Force. (Col. Heavner hinted that the project may be upgraded to a transceiver.)

One major study effort required now is to determine whether the different functional blocks are compatible. As yet Westinghouse has not tried to put together several molecular electronic functional devices. The company has combined two audio amplifiers to produce one bigger amplifier.

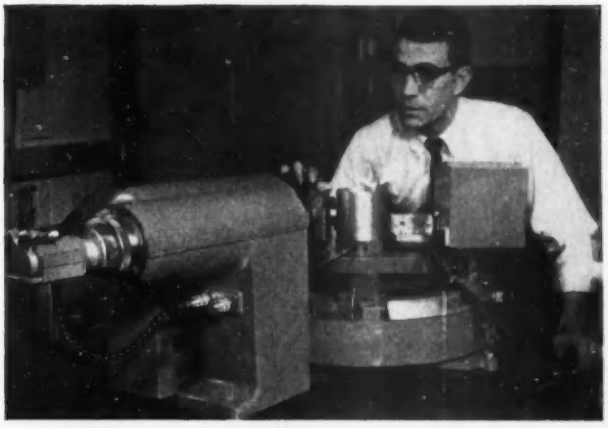
If the functional devices are compatible, engineers will have the choice of putting together several subsystems, each made of a single piece of semiconductor material, to build a system or carrying out additional research and development to produce the entire system out of a single piece of material. Col. Heavner said he thought that military applications in which reliability is more important than cost would lean on the single piece approach. Herwald thought commercial applications, which have to be justified economically, are likely to end up with several molecular subsystems.

• **How they do it**—The key to Westinghouse's molecular devices is a dendritic material in which germanium crystals in the form of ribbons about one-eighth of an inch wide and a few thousandths of an inch thick are produced by drawing them rapidly from a molten mass. Normally semiconductor crystals are grown slowly as large ingots.

Next step is to produce the necessary domains and interfaces required. At present Westinghouse uses conventional semiconductor manufacturing techniques: diffusion, plating, electron beam machining, etching, cutting, radiation, alloying, and photographic processes. But it may be possible to draw the one-piece device as a dendrite directly from the molten semiconductor.

HE X-RAYS WOOD...

to help make telephone poles last longer



Chemist Jack Wright developed the use of this X-ray fluorescence machine for testing the concentration of preservatives in wood. Here he bombards a boring from a test telephone pole with X-rays.

This Bell Labs chemist is using a fast, new technique for measuring the concentration of fungus-killing preservative in telephone poles.

A boring from a test pole is bombarded with X-rays. The preservative—pentachlorophenol—converts some of the incoming X-rays to new ones of different and characteristic wave length. These new rays are isolated and sent into a radiation counter which registers their intensity. The intensity in turn reveals the concentration of preservative.

Bell Laboratories chemists must test thousands of wood specimens annually in their research to make telephone poles last longer. Seeking a faster test, they explored the possibility of X-ray fluorescence—a technique developed originally for metallurgy. For the first time, this technique was applied to wood. Result: A wood specimen check in just two minutes—at least 15 times faster than before possible with the conventional microchemical analysis.

Bell Labs scientists must remain alert to *all* ways of improving telephone service. They must create radically new technology or improve what already exists. Here, they devised a way to speed research in one of telephony's oldest and most important arts—that of wood preservation.

Nature still grows the best telephone poles. There are over 21 million wooden poles in the Bell System. They require no painting, scraping or cleaning; can be nailed, drilled, cut, sawed and climbed like no other material. Scientific wood preservation cuts telephone costs, conserves valuable timber acres.

BELL TELEPHONE LABORATORIES

World Center of Communications Research and Development

WHAT'S NEW

Cold Gyro Approaches Perpetual Motion

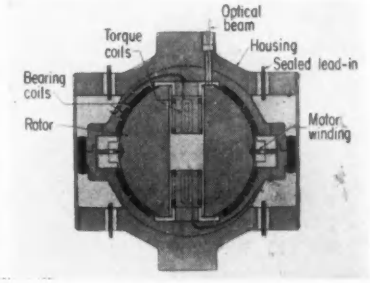
A cryogenic gyroscope that will have a life and accuracy an order of magnitude better than the best present day experimental gyro is the target of a development program at General Electric Co. Aptly named Project Spin, it is being carried out on a $214,000 contract from the Army Ballistic Missile Agency. Combined with a cryogenic guidance computer, such a gyro should provide a small, accurate and reliable inertial guidance and navigation package.

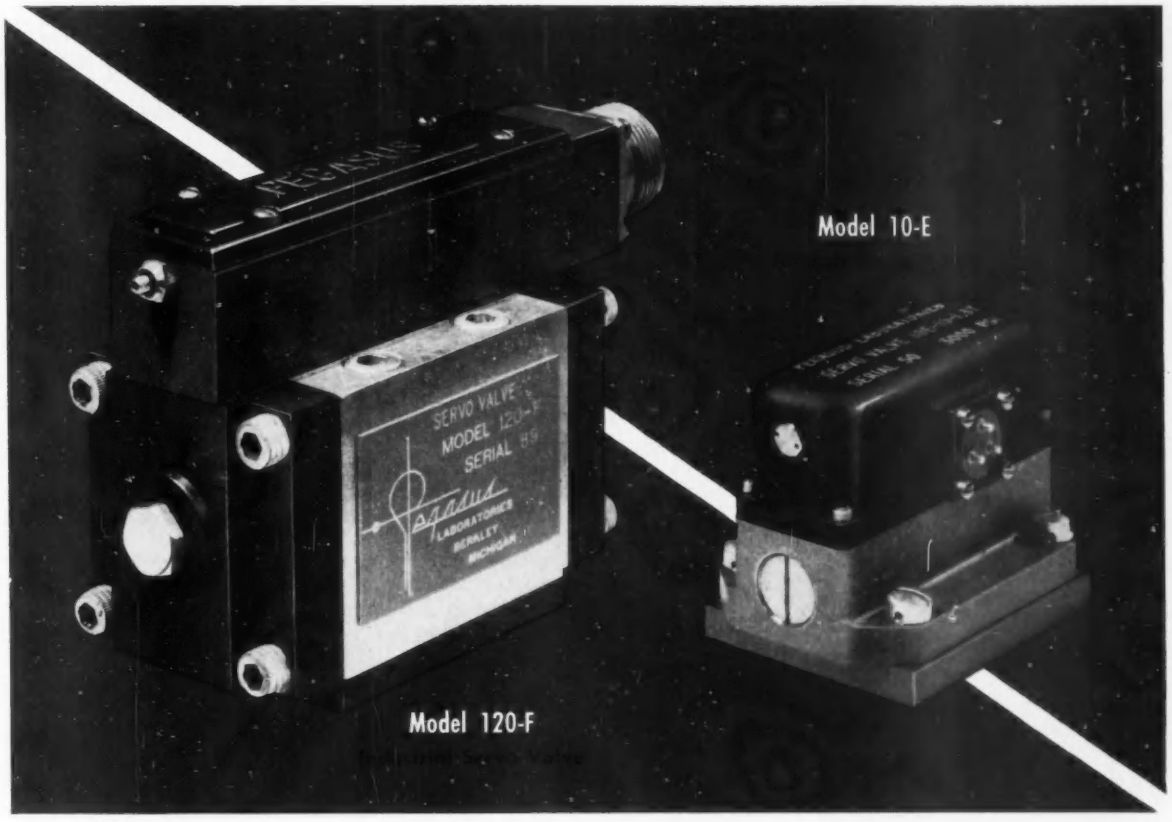
Key to the cryogenic gyro is the magnetic field resistance of superconductors. When cooled to close to absolute zero, certain metals (GE is experimenting with niobium) become almost perfect conductors. Magnetic fields below a critical field strength will not penetrate a superconductor since counter currents set up in the skin of superconductive metal create a permanent field that opposes the original magnetic field. This field resistant quality generates a repellent force that varies as the square of the flux density in the airgap.

Such phenomena, plus the fact that a current trapped in a coil of superconductive metal creates a magnetic field that stays constant indefinitely, makes possible a cryogenic magnetic bearing and in turn a cryogenic motor—the two elements necessary for a cryogenic gyro.

Motors have been constructed with polyphase superconductive windings and cylindrical and spherical rotors, made possible by tricky design features that cause the rotating magnetic field to apply the repellent force off-center on the rotor, thus transmitting torque. In a high vacuum, these motors run at nearly 100 percent efficiency, approaching perpetual motion.

Spherical bearing and motor in gyro.





PEGASUS for the Finest in Industrial and Aircraft Servo Valves

Pegasus Industrial and Aircraft Servo Valves utilize a powerful force motor and frictionless spool boost system which requires very low input power yet provides extremely high valve spool drive stiffness.

This high spool drive stiffness, as well as the completely symmetrical design, insures fine sensitivity without dither and low null shifts over large ranges of operating pressure and temperature.

Only 10 micron filtration is required for long, reliable performance.

Pegasus valves are now being shipped with complete electrically recorded data on the flow gain, linearity, hysteresis, leakage, pressure gain and sensitivity, to lower your receiving inspection costs.

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PEGASUS LABORATORIES, INC.

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CIRCLE 39 ON READER SERVICE CARD 39

EUROPEAN REPORT

The Russians Buy a Tire Plant

First details of the controls that will make the new Dnepropetrovsk tire plant one of the most automatic in the world. The Russians have bought the $42 million plant as a complete package from an English syndicate.

What may be the world's largest tire plant is now being built in Britain, assembled in parts for shipment to Russia. Late this year the plant is scheduled to start producing at a rate of two million tires annually. A British combination—Simon Handling Engineers Ltd., Francis Shaw Ltd., Mather and Platt Ltd., Lancashire Dynamo Holdings Ltd., Crompton Parkinson Ltd., and David Bridge and Co.—is supplying the $42 million plant which will cover 79 acres in Dnepropetrovsk, Ukraine. Consultant for the project is Dunlop Advisory Service of Dunlop Rubber Co.

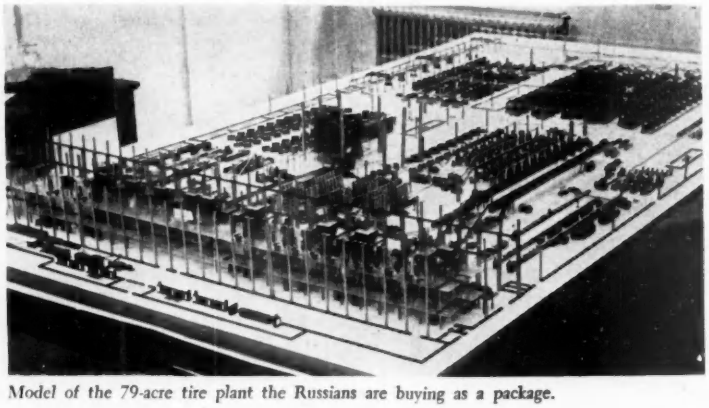
A variety of British-made control systems is being incorporated in the Russian plant. For example, some of the first complete punched card systems for weighing all tire ingredients, digital production control, nucleonic gage control of the calendar lines, and automatic control of the extensive conveyor handling systems for material and component flow between machines are included.

• **Production control**—To monitor production, centralized data logging equipment, built by Digital Engineering Ltd. (London), will record the output of the Banbury mixers, tread extruders, vulcanizers, presses, and tire building machines. Such output information will be stored on each machine in a latch relay; Micro switches fitted on each machine signal machine operation to the temporary memory. At regular intervals a scanning switch examines the state of the memory and feeds pulses from the energized relays to a three-decade stepping switch counter via a coding box.

Mounted back of each machine, the coding box is set for a particular mix, tire, or tire component. By setting the coding switch, time for each different manufactured item is accounted for. Slave clocks registering minutes, hours, days, months, and years are driven by a master pendulum initiating readout of the counters to obtain an hourly production record.

Diode matrices convert the stepping switch counter positions into teleprinter code to operate a tape perforator. The tape feeds from the perforator into a page printer which turns out production figures tabulated under each component item, regardless of which machine fabricated the item. Since the plant is designed to operate on a continuous basis, shift records of each item are printed out every eight hours from a cumulative count which is maintained in the second counter.

• **Mill room controls**—Manufacturing hub of the plant is the Mill room where the Banbury mixers will be installed along with their individual punched card ingredient weighing



Model of the 79-acre tire plant the Russians are buying as a package.

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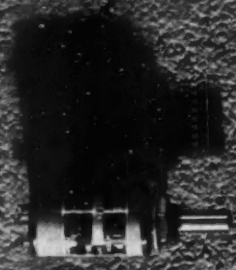

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WHAT'S NEW

systems. Raw rubber will be brought into the plant by chain conveyors; dielectric heaters alongside the conveyors will thaw out the stock during winter months.

Alongside each Banbury mixer are local storage hoppers to provide automatic feed of its raw materials: rubber, carbon black, oils, and powders.

One of these hoppers stores pelletized rubber and is supplied from a main storage silo which is divided into compartments holding 2,000 lb. A capacity level gage on the local hopper signals a need for replenishment. The low level signal sets up the 5-psi pneumatic conveyor connections between the hopper and the silo's bottom compartment. Latch relay memory circuits line up the local hopper demands if the silo discharge circuits are already filling a hopper.

Chain conveyors with automatic route setting devices distribute the other ingredients to their various machines. Sulphur and accelerator powders are stored in local hoppers. Level transducers automatically signal low levels to a manual loading station where an operator can tip sacked powders onto any of six chain conveyors. Required oils feed from six storage tanks served by a ring main.

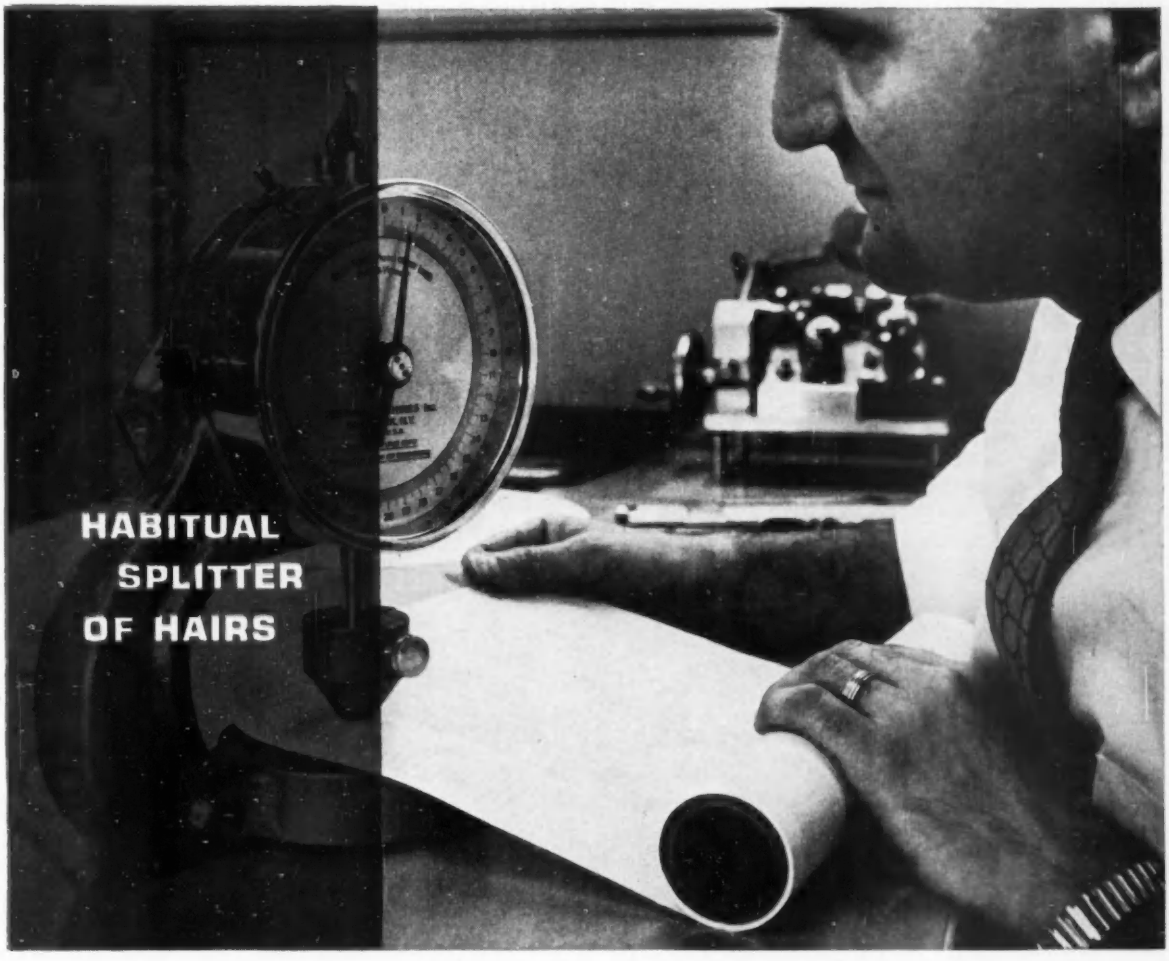
• **Punched card weighers**—Initial mix of the ingredients is controlled from a punched card weighing system, the Select-o-weigh, manufactured by Simon Handling Engineers Ltd. Total weighing cycle takes two and a half minutes, is controlled by a 65-column punched card.

Rubber pellets are first drawn from the local storage hopper and weighed. A known weight of fillers is added as the conveyor moves along with the rubber. Carbon black and oils are then weighed out, the oils being discharged to a blow tank for injection into the Banbury mixer by a special device that reduces oil wastage.

Correct delivery sequence of materials into the mixers is controlled on a time cycle with auxiliary temperature cycle control. On completion of the initial mix, the rubber is automatically discharged and repelletized to allow accurate weighing of a second mix. The punched card system also controls the small quantity of curatives and accelerator chemicals added to the mix.

After automatic ejection of the second mix, strip conveyors deliver the hot rubber to the calendar lines where X-ray gages control the thickness of rubber deposited on tire fabrics.

—Derek Barlow



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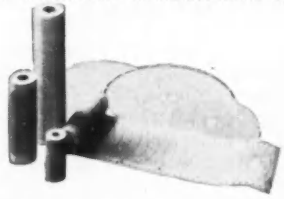
GC Recording Charts have become standard equipment in more than 5,000 plants today. We stock more than 15,000 different charts—and will design and produce accurate special-purpose charts. Send for our 1960 Stock List — and for sample charts.



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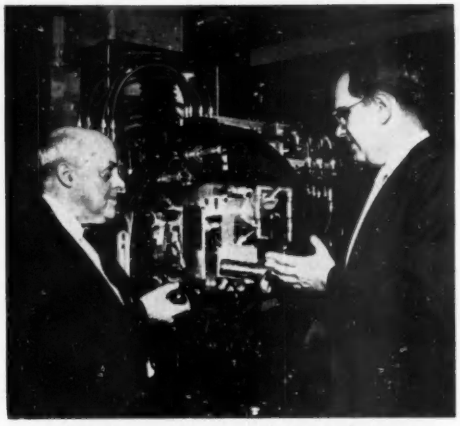
CIRCLE 43 ON READER SERVICE CARD 43

K&T's Star Performer

Just a year ago Kearney & Trecker introduced Milwaukee-Matic, a numerically controlled general purpose machine tool. This month CtE went to Milwaukee to find out how this machine fared in its first year. The conclusions: sales are booming, user savings are better than expected, and new markets are opening up.



Sales Manager Joerger (right) and designer Brainard pose with their star performer, K&T's Milwaukee-Matic (C&E Mar. '59, p. 27).

MILWAUKEE—John R. Joerger, sales manager at Kearney & Trecker Corp.'s Numerical Control Div. is a busy man these days—and a happy one. Just a year ago, when K&T introduced Milwaukee-Matic, a numerically controlled multipurpose machine tool that can mill, drill, ream, tap and bore parts, the company was optimistic about its prospects. Joerger finds that the first year has confirmed this optimism.

▶ Item: Because of the success of the Milwaukee-Matic, K&T was able to keep its Special Machinery Div. plant operating at top speed. Few other machine tool builders could make a similar claim in what was a so-so year for the industry. And K&T's other divisions did not fare nearly so well.

▶ Item: K&T turned out more numerically-controlled machine tools last year than any other company in the industry.

▶ Item: In 1959 K&T wrote orders for 55 Milwaukee-Matics and delivered 30, leaving a backlog of 28 machines.

▶ Item: Currently, the company has scheduled 115 machines, has already sold half of them. It expects to have a backlog of 30 orders going into 1961.

• **It started at AMC**—The history of Milwaukee-Matic goes back to the Air Materiel Command's interest in numerical control. K&T began planning for a flexible machine half a dozen years ago when a slackening in the demand for standard machines began to appear. K&T's Special Machinery plant was built with one eye on such a trend; the way had been paved by AMC's purchase of numerically controlled skin mills and profilers. K&T received about 25 percent of that business.

Under the guidance of Chief Engineer Wallace E. Brainard, Milwaukee-Matic evolved. It was a flexible tool that could perform automatically its many operations on parts in small quantities, in any sequence, on several sides of a workpiece, in any setup. Normally, this requires several machines and numerous jigs and fixtures. In Milwaukee-Matic, tool selection, indexing the worktable, spindle position, and other functions are controlled by a General Electric Co. punched tape system, programmed from drawings without a computer.

• **Skimming the cream**—In its first year of selling Milwaukee-Matic, K&T "skimmed cream" off the top of the market. This meant mainly companies handling military contracts.

K&T had expected that airframe manufacturers would prove to be the biggest customer group. But missile component builders—makers of guidance equipment, servocontrols, fuel metering equipment, and the like—turned out to be the most eager buyers. The reasons: these companies have to live with frequent engineering design changes; they found the flexibility of Milwaukee-Matic handled such changes easily.

Other early customers included jet

engine makers; machine tool builders; hydraulic valve fabricators; and builders of electrical machinery, shoe machinery, and general machinery.

In 1960 Joerger will train his sales guns on the general market, the hundreds of job shops that make parts in quantities anywhere from 5 to 50. Lessons learned during the first year will shape K&T's sales effort.

• **The small company benefits**–His first selling job is to make sure the potential customer understands that Milwaukee-Matic is primarily for small lot production, not mass production. And no computer is needed, a mistaken impression held by many potential buyers because some numerically controlled machines tools have required computer programming.

"Actually, what we are selling is a whole new philosophy of manufacturing," says Joerger. "We point out that other factors than tooling and labor costs have to be considered in the financial evaluation of Milwaukee-Matic. Tooling and labor savings are not necessarily the biggest savings to be obtained."

Originally, K&T asked potential customers only to send parts for analysis to determine economic justification. Now a lot of other information is requested to point out additional advantages. Since the machine costs $145,000, a major investment for even a large company, the fringe benefits are also important.

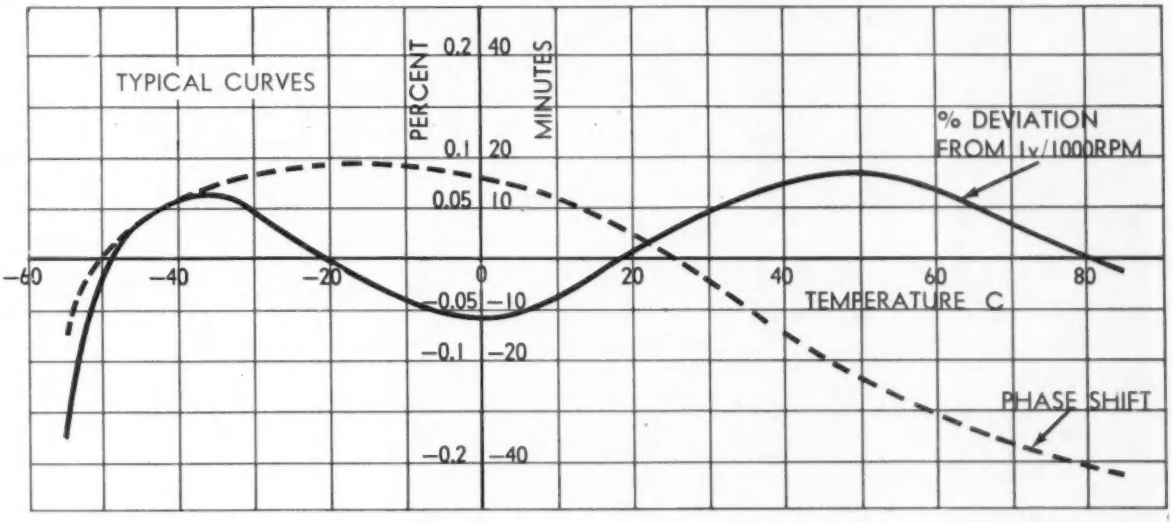
Users have found that Milwaukee-Matic will do the work of four or five machines and that it makes a chip about 60 to 65 percent of the time (vs about 12 percent of the time for the average machine tool). Tooling costs can be reduced in general from one-third to one-tenth of the original cost, according to Joerger. In one case the tooling cost for a jet engine component was reduced from $180,000 to $18,000, he says.

Chandler Evans Corp., West Hartford, Conn., reported it reduced setup time for one component from 21 to 6 hours with Milwaukee-Matic. On another part its tooling costs were reduced from about $10,000 to $3,000.

• **Handling service**–Both K&T and General Electric operate service and maintenance schools–K&T in Milwaukee and GE at Waynesboro, Va., where its Specialty Control Dept. is located. Usually only two or three men in a customer's organization can attend these schools so K&T also performs some on-the-job training. Programming is taught at K&T at a three-

New Ketay size 15 integrating motor tachometer —

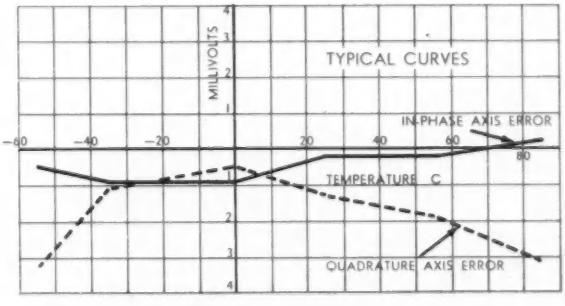
- **REQUIRES NO WARM-UP TIME**
- **USES NO HEATERS**
- **HAS 1.0000 VOLT PER 1000 RPM OUTPUT GRADIENT OVER ENTIRE TEMPERATURE RANGE**



The Ketay integrating motor tachometer, Type 105P2Y has many features that assure high output-to-null voltage ratios and extreme accuracy over the entire temperature range of −55°C. to +80°C.

In addition, the Type 105P2Y will give instantaneous response, for no warm-up time is required at any temperature within the operating range. The Ketay design uses no heating elements, mechanical thermostats, amplifiers or external heat sources and, as a result, the unit has increased life, less weight and less power drain on the over-all system.

The unit will pass military environmental specifications called out in MIL-S-17806.



CHECK THESE GENERATOR SPECIFICATIONS:

Excitation (volts)	115
Frequency (cps)	400
Input current (nominal) amps	0.0275
Input power (nominal) watts	1.9
Output gradient per 1,000 RPM @ 25°C.	1.0000 ± .05%
Phase shift with respect to input at 3600 RPM @ 25°C.	0° ± 10′
Null voltage at 25°C. (Maximum Values)	
IN-phase Fundamental at zero speed	2MV
Quadrature Fundamental at zero speed	6MV
Total harmonic	10MV(RMS)
IN-phase axis error	1MV
Quadrature axis error	1MV
Linearity — 0 to 4000 RPM (percentage of voltage output at 3600 RPM)	± .06%
Variation in output gradient with variation in ambient temperature (− 55°C. to +80°C.)	± 0.2%
Variation in axis error with variation in ambient temperature (− 55°C. to +80°C.)	± 7MV ± J8MV
Variation in phase shift with variation in ambient temperature (− 55°C. to +80°C.)	± 1°
Warm-up time	None
Total unit weight (motor and generator)	15 oz.

Write for detailed specifications and drawings, or for information on other Ketay integrating and damping tachometers.

KETAY DEPARTMENT

WHAT'S NEW

day school. Normally one or two persons from a customer's organization can attend. The machine tool builder estimates it can make a programmer out of a process engineer in two days. When the engineer returns to his plant, he makes some sample tapes and sends them to K&T for review.

• **Getting on line**—To put a machine into production at the customer's plant—erection and proveout tooling—usually takes about six weeks. This is a vastly shorter time than the year or so it took to start the first tape machines producing several years ago. Even back in 1956, K&T thought it was doing well to get a tape machine into regular production in three months.

One interesting aspect of K&T's experience has been the way the company has worked with General Electric, the control supplier. GE has several resident men at K&T, and when a machine is sent to a plant for installation, a GE man marries the control into the machine. However, K&T is the sole responsible party, and anything that goes wrong either with the machine or the control is reported to Milwaukee.

• **No bugaboos in control**—Performance of the controls in Milwaukee-Matic have been a "very pleasant surprise", says Joerger, adding: "The controls problem is not the bugaboo that the buyer frequently expects." The GE unit uses a combination of proven components—Kellogg switches, Ferrand scales, etc.—rather than any totally new designs.

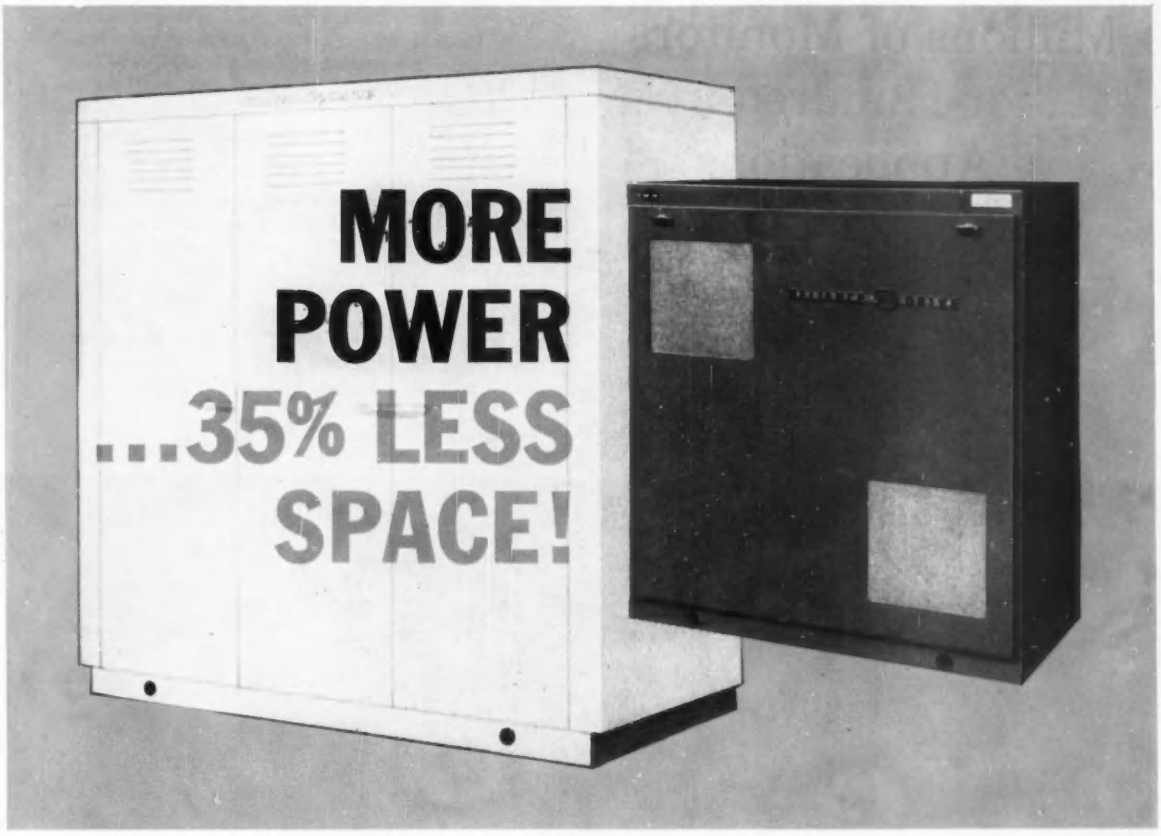
In preparing training literature for the men who will handle Milwaukee-Matic in the plant, K&T has revised its basic concept somewhat so as to stress the interrelationship between the mechanical and control functions.

New manuals, now being prepared, will provide a more comprehensive and elementary approach to the interweaving of the controls with the mechanical than anything done heretofore in the machine tool industry, says Joerger. "This approach—something like the Army GI's instruction manual—is designed to make it possible for any man who can read a manual to make an adjustment."

In addition, K&T is applying a coordinated approach to its regular training program and has appointed one man to be in charge of all phases of training—tooling, maintenance, programming, and operations. Each specialist who comes in for the training program is now being taught his rela-

(*Continued on page 206*)

Reliance Super 'T' V★S Drives



Both of these control units are rated at 50 horsepower! Actually, the new, small Super 'T' V★S cabinet packs more punch!

LIKE the Reliance Super 'T' Drive Motor, new V★S power units utilize Class B insulation, permitting a more compact unit. 100% overloads of one minute duration are accomplished without failure! Advanced design of ventilation keeps control and power units cooler . . . another reason why smaller size is possible. And service life is substantially extended.

Matched system design of drive motor, power unit and controls produces a highly efficient, integrated drive—to give you a wide range of stepless, variable operating speeds from a-c. circuits.

Super 'T' V★S Drives are available for immediate delivery. Check your Reliance salesman for delivery schedules on the full line, 1—350 hp., Bulletin Number D-2506, has been prepared to give you complete information. Write for it. D-1641

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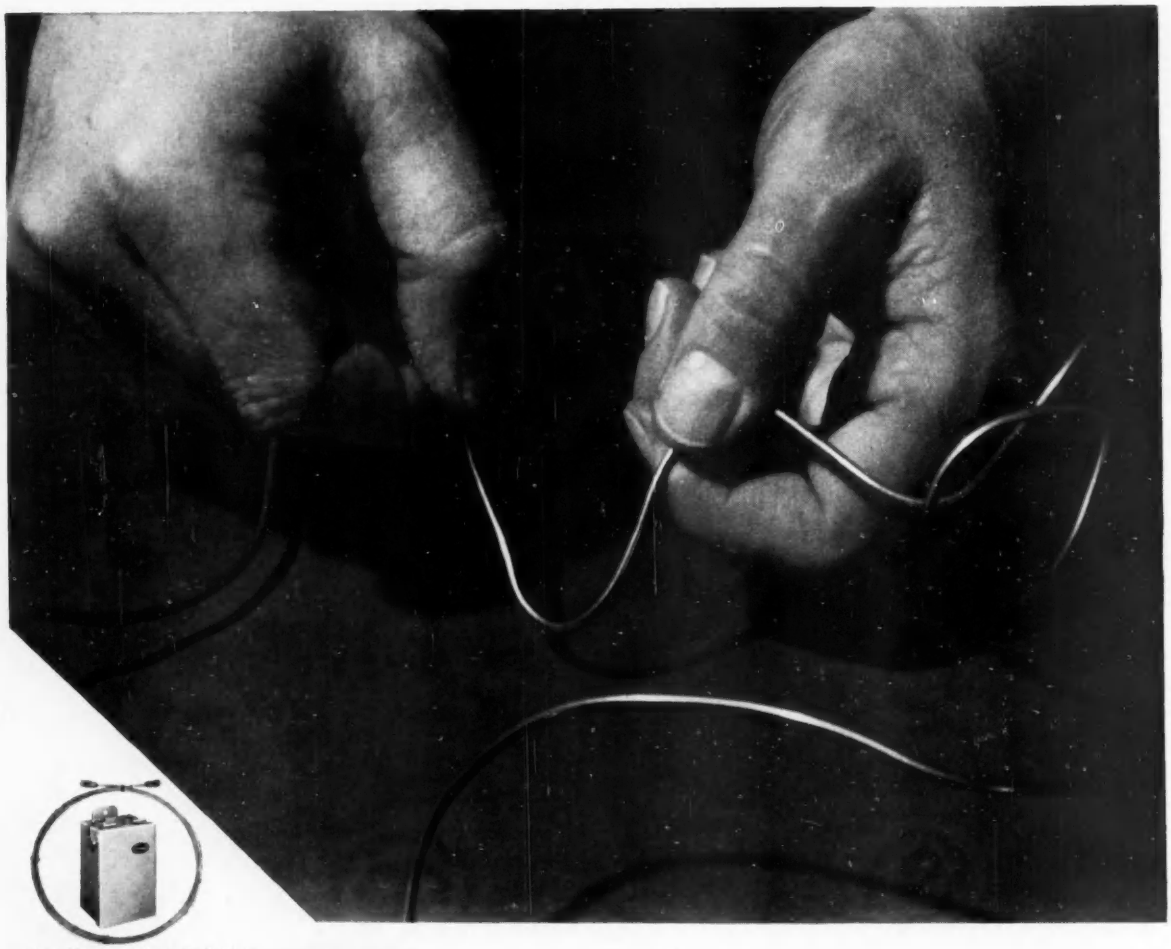
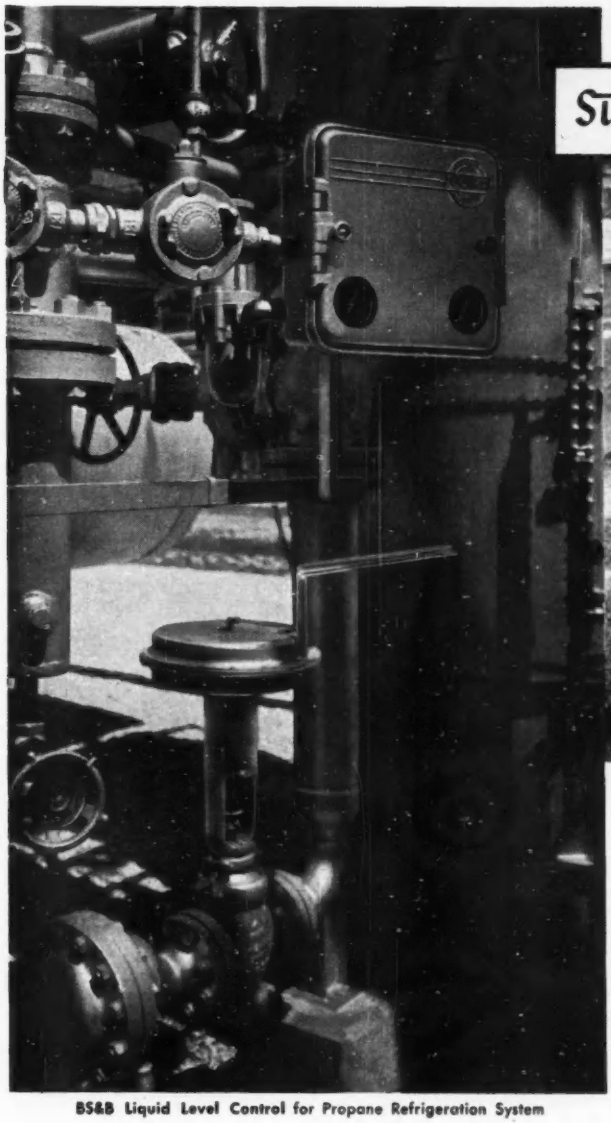
If you have many points to monitor, chances are a *flexible* Fenwal Line Temperature Detector . . . formed to your exact configuration . . . would help. Talk the application over with a Fenwal Sales Engineer. Write Fenwal Incorporated, 293 Pleasant Street, Ashland, Massachusetts.



Line Temperature Detector

Another example of how **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY



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Super 70's "On Stream"

Super 70 Diaphragm Control Valve
as Debutanizer Reflux Flow Controller

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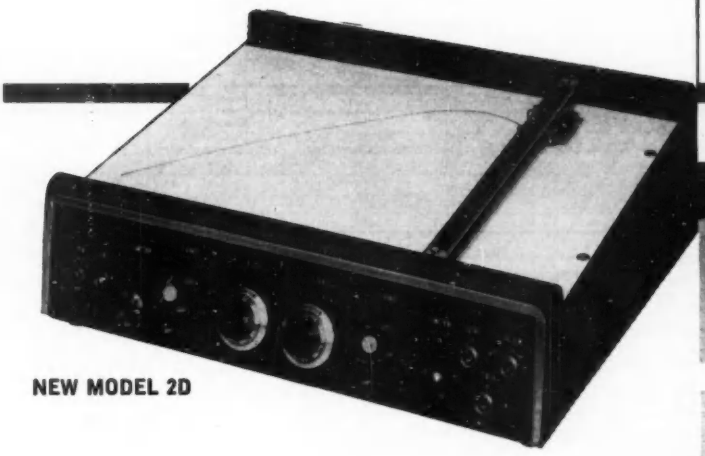

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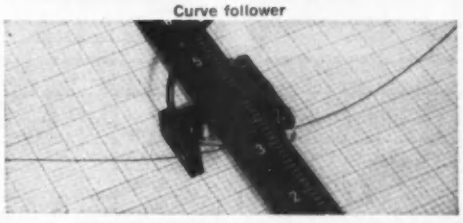
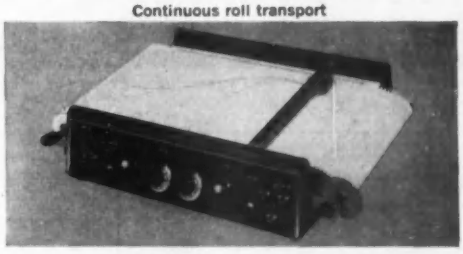


Continuous roll transport



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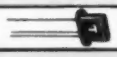
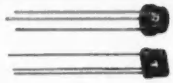
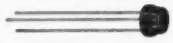
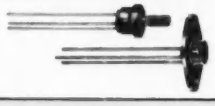
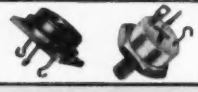
	JAN-2N118	10	30	10	1	• Only Jan Silicon Transistor

SMALL SIGNAL		Minimum Current Gain (B)	Maximum Collector Voltage (Volts)	Typical Cut-off Frequency (MC)	Maximum I_{co} @ 25°C and V_c Max. (μa)	FEATURES
	2N333	18	45	7	50	• Low I_{co} • Operation to 175°C • 200 mw Power Dissipation
	2N335	37	45	10	50	
	2N480	40	45	11	.5	
	2N543	80	45	15	.5	
	ST905	36	30	10	10	

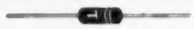
HIGH SPEED SWITCHING		Typical Cut-off Freq. (MC)	Maximum Collector Voltage (volts)	Maximum Collection Saturation Resistance (ohms)	Max. Power Dissipation @ 100°C ambient (MW)	FEATURES
	2N1139	150	15	60	500	• High Frequency Operation • Low Saturation Resistance • Low I_{co}
	2N337	20	45	150	50	
	2N338	30	45	150	50	

MEDIUM POWER		Max. Power Dissipation @ 25°C Case (Watts)	Maximum Collector Voltage (Volts)	Minimum DC Current Gain (B)	Typical Rise Time (μsec)	Typical Fall Time (μsec)	FEATURES
	2N545	5	60	15	.3	.5	• Fast Switching • High V_c • Rugged Construction
	2N547	5	60	20			
	2N498	4	100	12			
	2N551	5	60	20			
	2N1140	3	40	20	.2	.1	

HIGH POWER		Maximum Power Dissipation . . 25°C Case (Watts)	Minimum DC Current Gain (B)	Typical Collector Saturation Resistance (Ohms)	Maximum Collector Voltage (Volts)	FEATURES
	ST400	85	15 @ 2 Amps	1.5	60	• High Current Handling Ability • Low Saturation Resistance • Rugged Construction
	2N389	85	12 @ 1 Amp	3.5	60	
	2N424	85	12 @ 1 Amp	6.0	80	

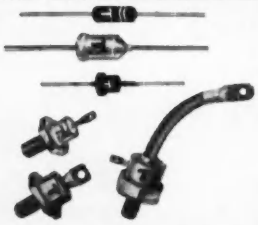
Write for Bulletins: TE-1353 and TE-1355

SILICON DIODES

	Fast Switching and High Frequency Types Ratings @ 25°C				Military and High Conductance Types Ratings @ 150°C			
FEATURES		Max. Inverse Voltage (Volts)	Max. Average Fwd. Current, (ma)	Inverse Recovery Time (μsec)		Max. Inverse Voltage (Volts)	Max. Average Fwd. Current (ma)	Max. Inverse Current (μa) @ V
• Recovery Times Under 15 μsec • High Conductance Combined With Fast Switching • Subminiature Size • High Inverse Resistance	1N808	100	100	.3	JAN 1N457	60	25	5 @ 60
	1N809	200	100	.3	JAN 1N458	125	25	5 @ 125
	1N658	120	200	.3	JAN 1N459	175	25	5 @ 175
	1N659	55	100	.3	1N485B	180	50	5 @ 175
	1N643	110	100	.3	1N488A	380	50	25 @ 380
	JAN 1N251	30	75	.15	1N464	175	40	30 @ 125

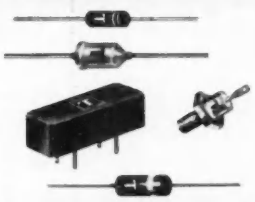
Write for Bulletin TE-1350

SILICON RECTIFIERS

Ratings @ 150°C Case Temperature			Peak Recurrent Inverse Voltage (Volts)	Maximum Average Forward Current (ma)	Maximum Inverse Current (ma)	FEATURES
	Subminiature Glass	1N689 1N649	600 600	150 150	0.2 0.2 (@ 25°C)	• Reliability at High Temperatures • High Efficiency • Rugged Construction • Hermetic Sealing • Low Thermal Resistance
	Miniature	TJ60A TJ30A	600 300	200 200	0.5 0.5	
	Axial Leads	SL715 1N547	1500 600	100 250	0.2 0.3	
	Military	JAN 1N256	570	200	0.25 (@ 135°C)	
	Stud Mounted	TM155 TM67	1500 600	400 3000	0.5 0.5	
	Medium Power	TR402 TR601	400 600	Amps 20 10	5 5	
	High Power	TH402B	400	50	15	

Write for Bulletin TE-1351

SILICON REGULATORS AND REFERENCES



	Voltage Range (Volts)	Maximum Dynamic Resistance (ohms)	Maximum Current @ 25°C (ma)	Maximum Current @ 125°C (ma)	FEATURES
Subminiature — SV-5	4.3-5.4	55	50	10	• Long-term stability • Operation up to 150°C • Small size, easy mounting • Hermetically sealed
Miniature — SV-815	13.5-18	120	40	8	
Power — SV-924	20-27	8	55°C (amps)* .4	(ma)* 100	
Stabistor — SG-22	.64	40	150	25	
Reference — SV-3176	8-8.8	15	Temp. Coefficient ≤.001%/°C		
Ref-Amp — 3N44	8.3-9.8		≤.002%/°C		

*Case temperature ratings

Write for Bulletin TE-1352

SILICON CAPACITORS

Ultra High Frequency Types — Ratings @ 25°C						FEATURES
	Cut-off Freq. (mc)	Capacity (μμf) @ V Max.	Capacity (μμf) @ −0.1V	Q @ −4V @ 50Mc	Q @ −4V @ 100Mc	Maximum Working Voltage	
SCH-51	5000	.35	2	100	50	10	• Subminiature Size • High Q • High Temperature Operation
SCH-52	5000	.8	4	100	50	7	

High Frequency Types						
				Q @ −4V At 5mc	Q @ −4V At 50mc	
SC-1		4.4	24	350	35	22
SC-5		25	120	350	35	11
SC-15		120	360	350	35	6

Write for Bulletin PB-45

GERMANIUM DIODES

FEATURES

- Milli Microsecond Switching
- Superior Forward Conductance
- High Inverse Resistance
- Uniformity and Stability
- Gold Bonded Construction

Specifications and Ratings at 25°C		Forward Current @ +1V (ma)	Inverse Current at Specified Voltage (μa @ V)	Max. Oper. Voltage (volts)	Description
	JAN-1N270	200	100 @ −50	80	JAN TYPES
	JAN-1N277	100	250 @ −50 @ 75°C 75 @ −10	100	
	JAN-1N281	40	500 @ −50 30 @ −50	60	
	JAN-1N126	5	500 @ −50 30 @ −10	60	
	JAN-1N198	5	250 @ −50 @ 75°C 75 @ −10	50	
	1N283	200	20 @ −10	20	COMPUTER TYPES
	T16G	40	100 @ −50	60	
	1N278	20	125 @ −50 @ 75°C	50	HI-TEMPERATURE TYPES
	T22G	40	20 @ −10 @ 75°C	15	
	T9G	100	20 @ −50 2 @ −10	60	HI-RESISTANCE TYPES
	1N67A	5	50 @ −50 5 @ −5	80	
	T8G	100	20 @ −100 5 @ −10	100	
	S570G	10	30 @ 6	Recovery Time .002 (μsec)	MILLI-MICROSECOND SWITCHING

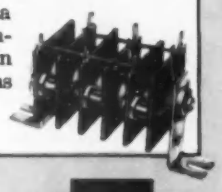
Write for Bulletin TE-1300 & TE-1319

GERMANIUM COMPUTER TRANSISTORS

	Minimum Current Gain (B)	Maximum Collector Voltage (volts)	Typical Cutoff Freq. (MC)	FEATURES
2N427	40	15	8	• High Frequency Switching • Low Saturation Resistance • Uniform Input Characteristics
2N428	60	12	13	

Your local authorized TRANSITRON DISTRIBUTOR now carries in-stock inventories for immediate delivery.

Transitron's TD series of rectifier stacks offer a wide range of ratings in seven standard circuit configurations. High voltage cartridges, quads, plug-in assemblies, and many other special encapsulations are also available. Your inquiries are invited.
Write for Bulletin TE-1342.

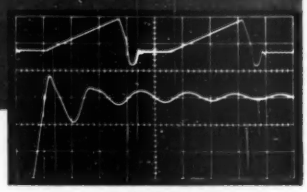


Transitron

electronic corporation • wakefield, massachusetts

CIRCLE 55 ON READER SERVICE CARD

NEW DC-to-30 MC DUAL-BEAM Tektronix Oscilloscope with Independent X and Y Deflection



SWEEP DELAY
Same signal displayed simultaneously on slow sweep (upper beam) and fast sweep (lower beam) shows both coarse and fine structure of waveform.

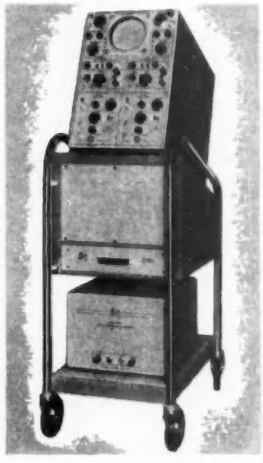
TYPE 555

Two electron beams, each with its own X and Y deflection systems, help make possible a highly versatile dual-beam oscilloscope.

Either of the two time-base generators in the Type 555 can deflect either beam for dual and single displays, and either can deflect both beams for a dual display on the same time base. Time-base units are the plug-in type to facilitate instrument maintenance.

With one time-base generator functioning as a delay generator, the start of any sweep generated by the other can be held off for a selected time interval with a high degree of accuracy. Both the original display and the delayed display can be observed at the same time. The "triggered" feature can be used to obtain a jitter-free delayed display of signals with inherent jitter.

Signal-handling versatility is provided by nine available types of plug-in preamplifiers, any combination of which can be used in the two fast-rise vertical channels. In addition to the many application areas opened with Tektronix plug-in preamplifiers, a three-channel or four-channel display is available through use of the time-sharing characteristics of Type C-A Dual-Trace Units in one or both channels.



Characteristics

INDEPENDENT ELECTRON BEAMS
Separate vertical and horizontal deflection of both beams.

FAST-RISE MAIN VERTICAL AMPLIFIERS
Passbands—dc-to-30 mc with Type K Units.
Risetimes—12 mμsec with Type K Units.
All Tektronix Plug-In Preamplifiers can be used in both vertical channels for signal-handling versatility.

WIDE-RANGE TIME-BASE GENERATORS
Either time-base generator can be used to deflect either or both beams.
Sweep ranges—0.1 μsec/cm to 12 sec/cm. 5 x magnifiers increase calibrated sweep rates to 0.02 μsec/cm.

SWEEP DELAY—Two modes of operation.
Triggered—Delayed sweep started after the delay period by the signal under observation.
Conventional—Delayed sweep started at the end of the delay period by the delayed trigger.
Delay range—0.5 μsec to 50 sec in 24 calibrated steps, with continuous calibrated adjustment between steps.

HIGH WRITING RATE
10-KV Accelerating potential provides bright traces at low repetition rates and in one-shot application.

REGULATED POWER SUPPLY
All dc voltages electronically regulated.
Heater voltages also regulated.

PRICE, Type 555 without plug-in preamplifiers **$2600**
Includes Indicator Unit, Power Supply Unit, 2 Time-Base Units, 4 Probes, Time-Base Extension.

Type 500A Scope-Mobile (as shown with Type 555) . . . **$100**

Type 500/53 Scope-Mobile
(with supporting cradles for plug-in preamplifiers) **$110**
Prices f.o.b. factory.

Tektronix, Inc.

P. O. Box 831 • Portland 7, Oregon
Phone CYpress 2-2611 • TWX-PD 311 • Cable: TEKTRONIX

TEKTRONIX FIELD OFFICES: Albuquerque, N. Mex. • Atlanta, Ga. • Baltimore (Towson, Md.) • Boston (Lexington, Mass.) • Buffalo, N.Y. • Chicago (Park Ridge, Ill.) • Cleveland, Ohio • Dallas, Texas • Dayton, Ohio • Denver, Colo. • Detroit (Lathrup Village, Mich.) • Endicott (Endwell, N.Y.) • Greensboro, N.C. • Houston, Texas • Kansas City (Mission, Kan.) • East Los Angeles, Calif. • West Los Angeles, Calif. • Minneapolis, Minn. • New York City Area (Albertson, L.I., N.Y. • Stamford, Conn. • Union, N.J.) • Orlando, Fla. • Philadelphia, Pa. • Phoenix, (Scottsdale, Ariz.) • San Diego, Calif. • San Francisco (Palo Alto, Calif.) • St. Petersburg, Fla. • Syracuse, N.Y. • Toronto (Willowdale, Ont.) Canada • Washington, D.C. (Annandale, Va.)

TEKTRONIX ENGINEERING REPRESENTATIVES: Hawthorne Electronics; Portland, Oregon • Seattle, Washington. Tektronix is represented in twenty overseas countries by qualified engineering organizations.

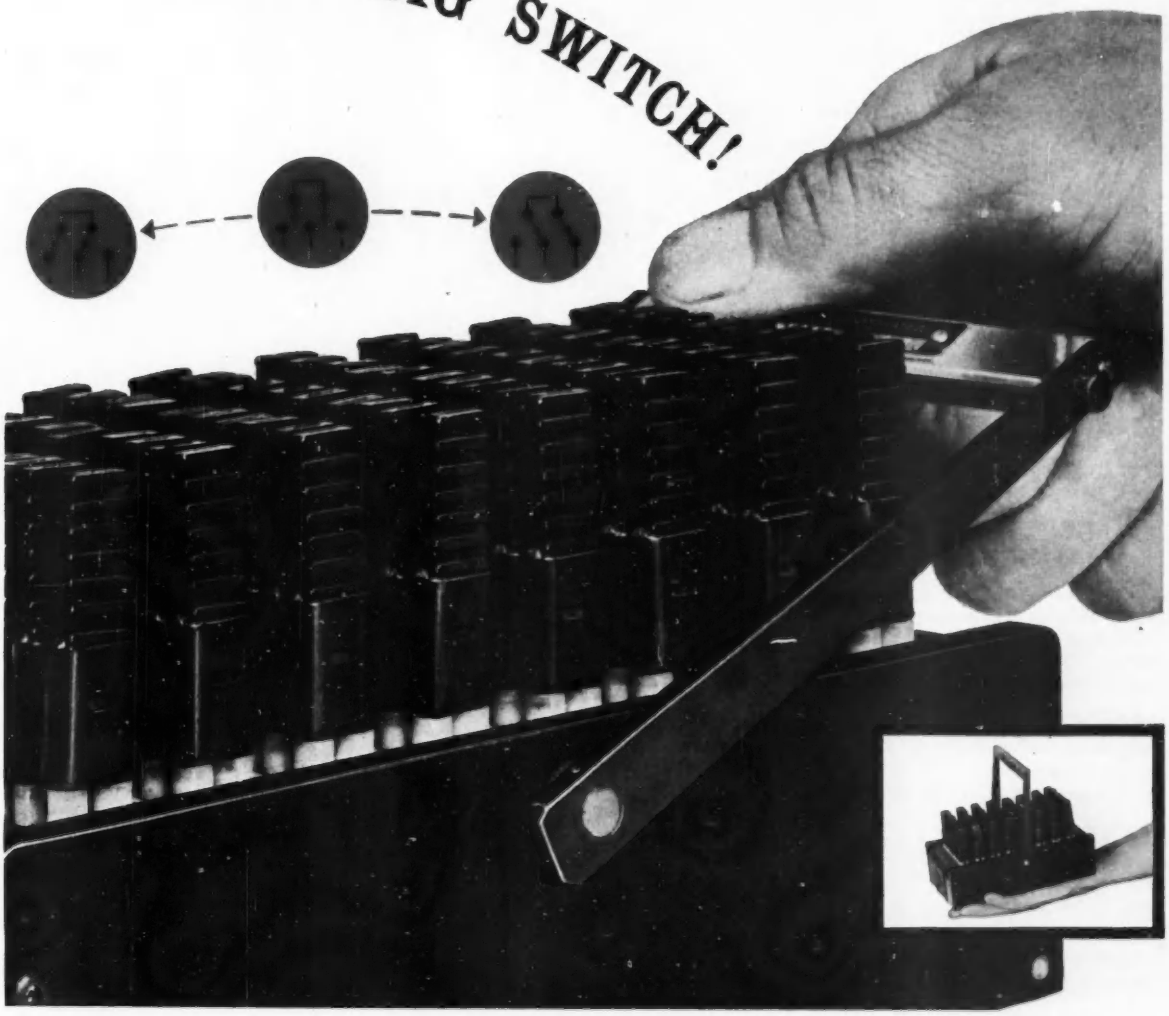
SEE THE NEW TEKTRONIX KMC OSCILLOSCOPE AT THE IRE SHOW—BOOTHS 3027-3030

Just flick your finger. That's all you do to select either of two circuit programs with AMP's new Program Selector Switch—up to 1500 poles, double throw. Compact in size, available in a fully shielded type, this new switch offers you all the reliability you need for any critical dry-circuit application.

The flick of your finger also pre-cleans all contacts for assured conductivity through AMP's patented wiping action. You get uniform pressure on all contacts . . . choice of tin or gold contact finish . . . exclusive contact and spring design plus many other features from AMP's industry-proved Patchcord Programming Systems . . . including A-MP Taper Pins, crimped to your leads and inserted into taper receptacles in the rear of the switch.

And—for flexibility, you can make a combination plug board and double throw switch with all throw positions independently patched.

THE BIG SWITCH!

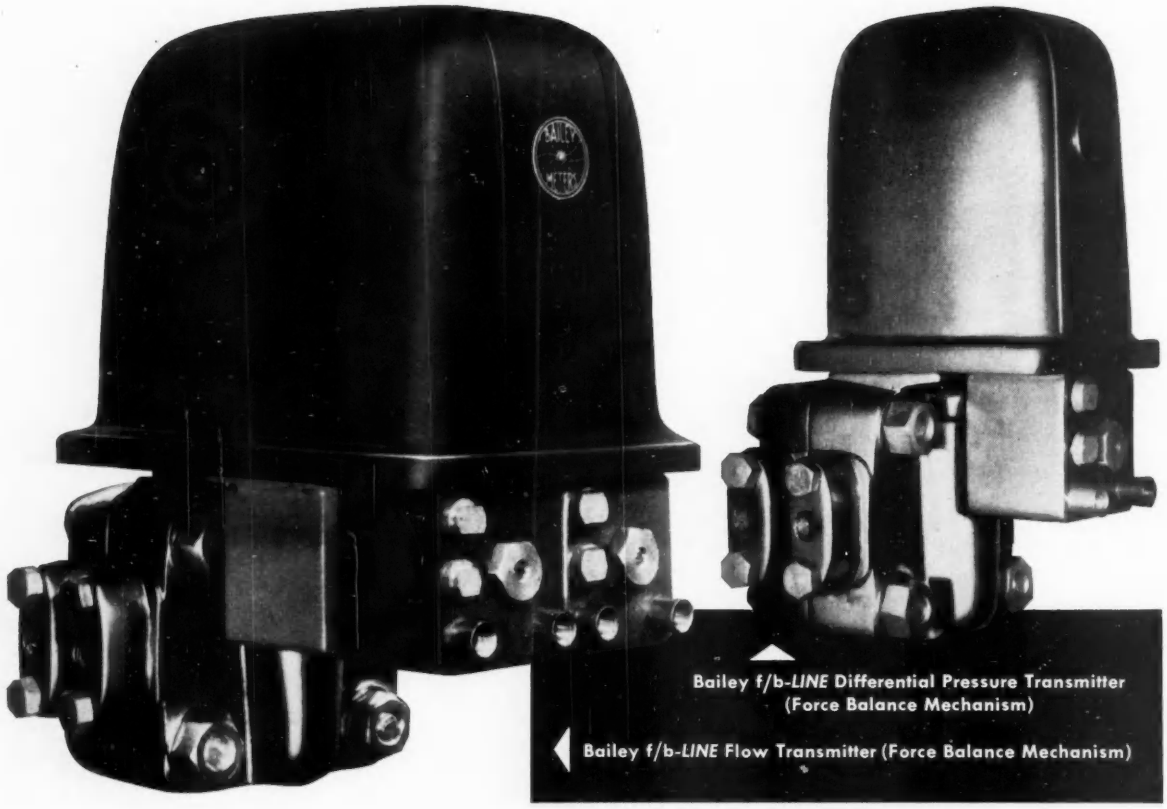


Make the big switch to the A-MP Double Throw Program Selector Switch. Send today for more information.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Japan



Bailey f/b-*LINE* Differential Pressure Transmitter (Force Balance Mechanism)

Bailey f/b-*LINE* Flow Transmitter (Force Balance Mechanism)

Two new Bailey *f/b-LINE* Transmitters

permit new accuracy in measuring flow and differential pressure

Pneumatically transmits rate of flow—or differential pressure—measurements to indicating, recording, and/or controlling equipment at remote stations. Transmitters consist of a diaphragm measuring mechanism and a force balance pneumatic transmitting unit.

APPLICATION

For steam, water, air, gases and other fluids producing differentials across primary elements from 0-2 in. H_2O to 0-2000 in. H_2O at maximum service pressure of 50, 1500, and 5000 psig.

FEATURES

Transmits a Signal Directly Proportional to Rate of Flow. Uses receiver with uniformly-graduated chart or scale. Eliminates need for external square-root extractors or characterizers.

10 to 1 Turndown. Differential range of each diaphragm measuring element may be changed by factor of 10 to 1; e.g., 0-20 in. H_2O diaphragm may also measure 0-2 in. H_2O.

Screwdriver Adjustments. Range and zero adjustments readily accessible. Range may be changed with screwdriver adjustment.

Overpressure Protection. Protects against full service pressure applied to either side of diaphragm.

Fast Response. No viscous dampers needed, so speed of response is very fast.

Corrosion Resistant. For maximum differentials between 20 and 2000" H_2O, all parts in contact with process fluid may be stainless steel. No sealing fluids or sealing diaphragm required.

Good Stability. Reset type boosters give good stability with high gain.

Versatile Mounting. May be mounted on process piping, wall, or separate mounting pipe using same bracket.

For additional information, call your local Bailey District Office, or write direct. G46-1

Instruments and controls for power and process

BAILEY METER COMPANY

1079 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

SEE... and HEAR...

THE DIGITAL SYSTEMS THAT SPEAK FOR THEMSELVES!

At New York IRE: In practical application for industrial process control.

From the field, from a proved capability, Cubic's fine precision laboratory instrumentation is applied to the automation of industrial processes and given hitherto unknown dimensions with a "readout" you can *hear*.

In the field and at IRE,
Cubic Digital Systems speak for themselves . . .

DC VOLTMETER: Proved stability of .003% and noise rejection as high as 200%

AC CONVERTER: Proved operation to 90 kc, with accuracy exceeding specifications

OHMMETER: Proved shock-safe with controlled open-circuit test voltage

RATIOMETER: Proved .003% attenuator accuracy for wide-range precision

SCANNING SYSTEMS: Proved reliability over weeks of automated transistor sampling

PRINTER CONTROL: Proved performance in data recording with every quality printer on the market.

. . . And the human-engineered Talking Meter,
for a vocal readout in any parameter.

When you're at New York IRE, stop by Cubic's booth and see the unique Weather Board monitored by a Cubic Digital System to give you the weather story across the nation . . . in digital and vocal report.

BOOTH 3235

Years-ahead engineering, factory production techniques inspired by pride in the end result, careful quality control and reliability testing . . . all these factors make Cubic's the truly fine instrumentation . . . Digital Systems that speak for themselves.

CUBIC INDUSTRIAL DIVISION CORPORATION
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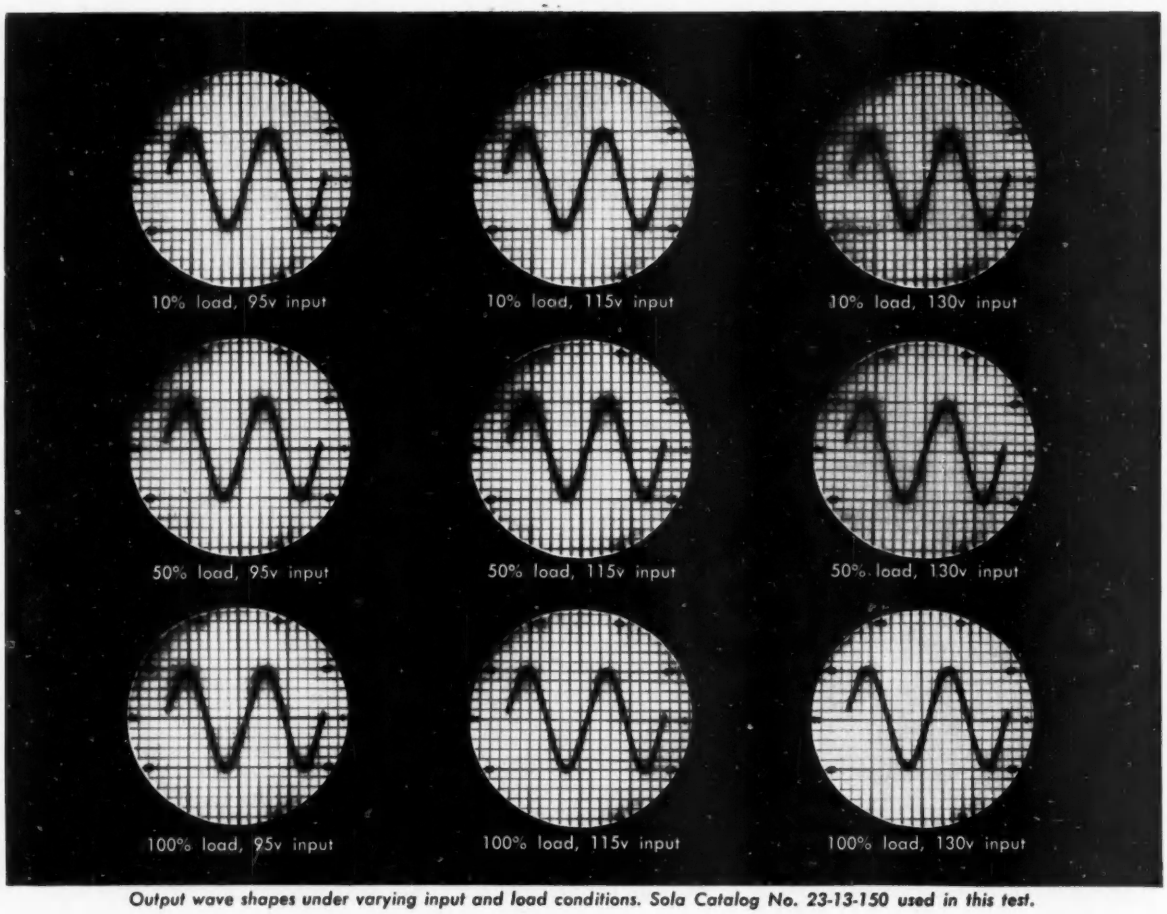
Electronic Engineering With a Dimension for the Future



Output wave shapes under varying input and load conditions. Sola Catalog No. 23-13-150 used in this test.

Sola's moderate-cost static-magnetic voltage regulator has sine-wave output

Sola now offers sinusoidal output in every standard-type regulator *with no price premium*. This development — a result of major design and production innovations — greatly widens the field of use for static-magnetic voltage regulation. The new standard sinusoidal design is now ideal for use with electrical and electronic equipment requiring a regulated input voltage with commercial sine wave shape — especially where harmonic-free supply had previously been too costly. The sinusoidal output also contributes to ease of selection and ordering, since this Sola stabilizer is virtually universal in application.

The Sola Standard Sinusoidal Constant Voltage Transformer provides output with less than 3% rms harmonic content. It automatically and continuously regulates output voltage within ±1% for line voltage variations of ±15%. Average response time is 1.5 cycles or less. The new line includes nine stock output ratings from 60va to 7500va.

Besides the improved electrical characteristics, these units are substantially smaller and lighter than previous models. Size and weight reductions were accomplished without any loss of performance or dependability.

With the Sola Standard Sinusoidal Constant Voltage Transformer you also get all the proved benefits of a static-magnetic regulator. It is simple and rugged. There are no tubes . . . no moving parts . . . no replaceable parts. Maintenance and manual adjustment are not necessary.

Its current-limiting characteristic protects against shorts on the load circuit. It is available in step-up and step-down ratios, allowing substitution for conventional, non-regulating transformers. These units can be used in any electronic or electrical application requiring a regulated sinusoidal power source where the peak power demand does not exceed the capacity of the constant voltage transformer. Circuit design formulae based on sinusoidal wave shape are directly applicable. Custom units to specific requirements are available in production quantities.

Write for Bulletin 26C-CVS

SOLA

SOLA ELECTRIC CO.
4633 West 16th Street Chicago 50, Illinois

BP C — **A Division of Basic Products Corporation**

CIRCLE 61 ON READER SERVICE CARD→

2N1069 2N1070

HIGH POWER—LOW SATURATION RESISTANCE NPN SILICON TRANSISTORS

Silicon Transistor Corporation is now delivering diffused-junction, NPN silicon mesa transistors. These new high power—low saturation resistance transistors operate in the temperature range of −65° C to +175° C for a wide variety of military and industrial applications where peak reliability and high temperature characteristics are required. Maximum saturation resistance for the 2N1070 is 0.67 ohms at a collector current of 1.5 amps., the 2N1069 is 2 ohms maximum at the same current.

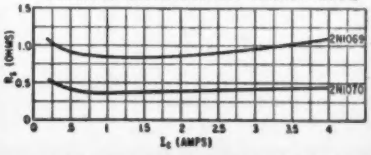
Applications: Since these STC transistors feature low saturation resistance they are ideally suited for switching applications as well as relay replacements and controls, solenoid actuators, power convertors, power switches, high level D.C. amplifiers, power supply regulators, and Class A and B power amplifiers.

For complete specifications, request STC Form 1953. Write also for engineering bulletins on STC's full line of silicon glass diodes.

IRE Booth Number 1105

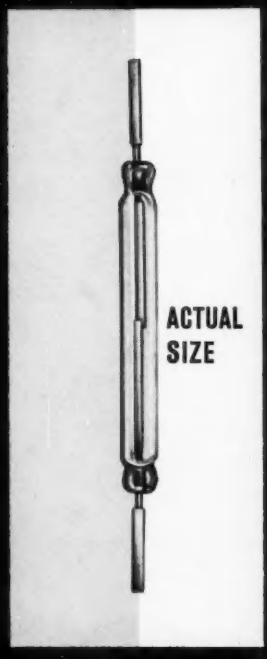
RATINGS	
Power Dissipation	50 watts
V_{CBO}	60 volts
V_{EBO}	9 volts
V_{CEO}	45 volts
I_C	4 amperes

TYPICAL SATURATION RESISTANCE



SILICON TRANSISTOR CORPORATION, Carle Place, L. I., New York, Ploneer 2-4100

NOW *from C.P. Clare & Co...*



Switch capsule of the new Clareed Sealed Contact Reed Relay consists of a pair of magnetically operated contacts, hermetically sealed in a glass capsule, in an atmosphere of inert gas.

SPECIFICATIONS

Contact Arrangement: Normally form A, form B, in combination form C

Overall length: 3-¼ in. max.

Outside diameter: 0.215 in. max.

Contact material: Gold

Contact rating: 15 volt-amperes max., non-inductive: 1 amp. max.; 250 volts max.

Contact resistance: 25-40 milliohms.

Life expectancy: At 14 volt-amperes (½ ampere, 28 volts dc), 20,000,000 operations.
At 7 volt-amperes (¼ ampere, 28 volts dc), 100,000,000 operations.

Minimum breakdown voltage: (60 cps) 500 volts rms.

Insulation resistance: 500 k megohms min.

Low level load test: 8 microamps, 800 ohms, 250 millivolts, open circuit operated at 3 ips, 100 million operations with no failures.

Switches per Coil	Watts to Just Operate Typical Coils	Milliseconds (including bounce) Operate Excess NI over P.U. 100	200	Release
1	0.25	1	0.8	0.25
2	0.30	1.5	0.9	0.25
3	0.35	2.2	1.5	0.25
4	0.42	3.2	2.2	0.25
5	0.52	3.5	2.5	0.25
6	0.8	5	3.5	0.50
12	1.5	6	5	0.50
20	3.5	8	6	0.50

CONTACT BOUNCE

At "just operate"	0.3 ms max.
At 200 excess NI	0.5 ms max.
At 400 excess NI	0.8 ms max.
No bounce on release.	

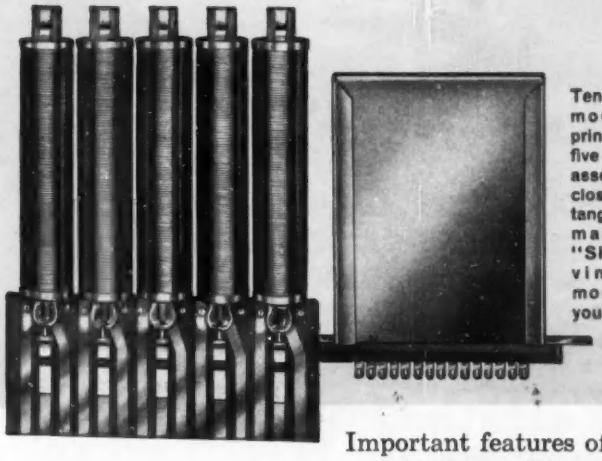
... CLAREED®

a New Concept in Relay Design

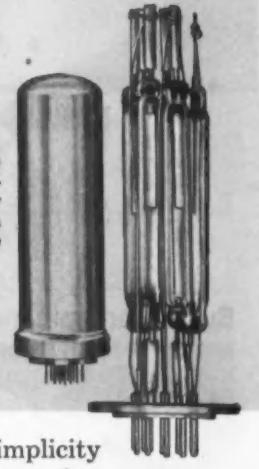
The new CLAREED Sealed Contact Reed Relay effectively eliminates contact contamination. With its contacts hermetically sealed in contaminant-free inert gas, this new design assures millions of perfect operations. Hundreds of millions are possible when operated at up to ½ rated contact load.

CLAREED relays are ideal components for transistor drive applications and for use in computers and data processing equipment. Their low inductance and the low inductance change in the operating coil at each operation limits the transients produced. Submit your packaging problem for recommendations.

• PACKAGED TO MEET *your* REQUIREMENTS



Ten CLAREED switches, mounted in line on a printed circuit board with five magnetic coils. This assembly can then be enclosed in the flat, rectangular container or it may be coated with "Skin-Pack," a tough vinyl plastic, and mounted directly into your equipment.



Six CLAREED switches clustered for mounting in a single tube container.

Important features of CLAREED relays are their simplicity and flexibility. They may be mounted to meet the requirements of almost any application and environmental condition, even on your own printed circuit board—to comply with your mechanical design configurations.

CLAREED relays are as flexible as your application requires. Consultation with your nearby CLARE sales engineer is invited. Additional information may be obtained from C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Limited, Box 134, Downsview, Ontario. Cable Address: CLARELAY. *Send for Bulletin CPC 5.*

SEE IT AT THE IRE SHOW
New York Coliseum
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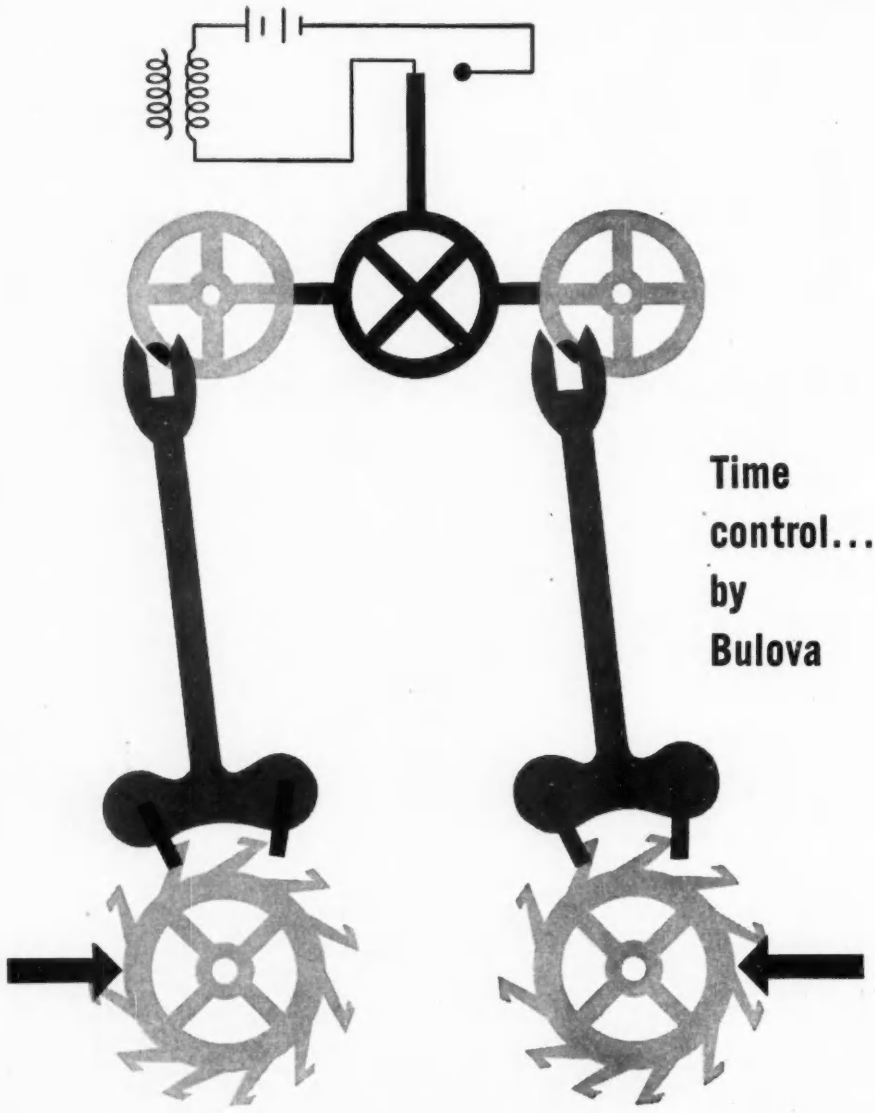
BOOTH NOS. 2218 & 2220

CLARE FIRST in the industrial field

CIRCLE 63 ON READER SERVICE CARD



Time control... by Bulova

Bulova hardware includes special purpose timers

Bulova pioneering has opened up whole new areas in metering time and distance —has lead to refinements in simplicity, reliability and cost reduction.

Bulova talent and production know-how can easily satisfy your needs for reliable special purpose timers, whether they call for simple runaway escapements or complex dual channel mechanisms.

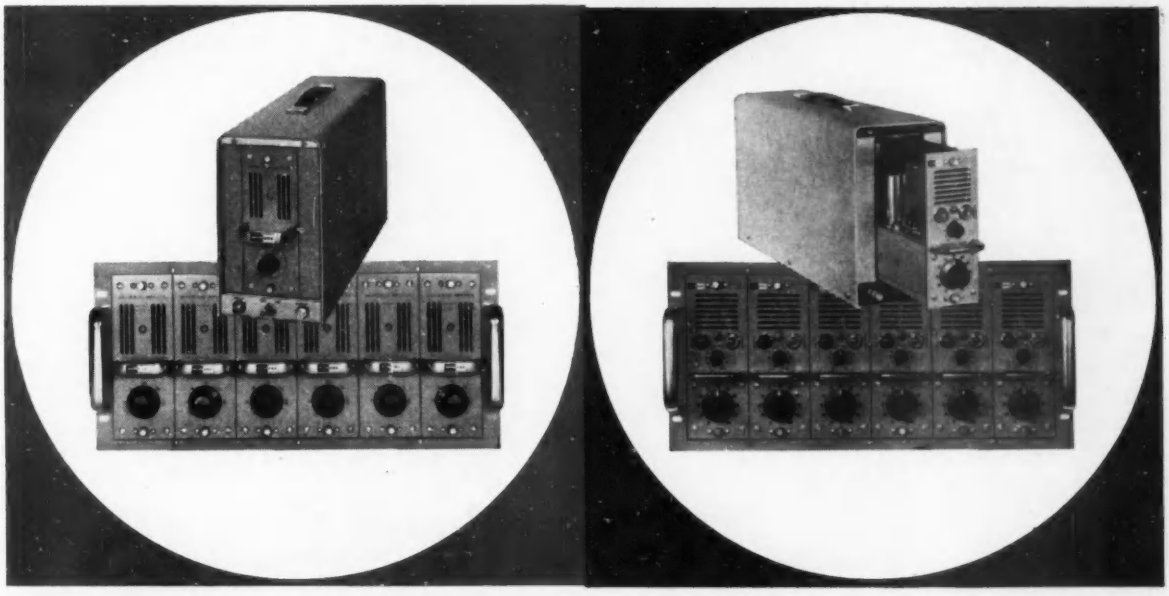
Experience in precision design and manufacture is the Bulova tradition—the Bulova capability—it has been for over 80 years. For more information write—

Industrial & Defense Sales, 62-10 Woodside Avenue, Woodside 77, N.Y.

BULOVA

Visit our Booth Numbers #1719—#1721 I.R.E. Show—N.Y.C.

AMPLIFY MICROVOLTS WITH STABILITY... measure strain, temperature, other phenomena, to 0.1% with a KIN TEL DC amplifier



NEW...TRUE DIFFERENTIAL DC AMPLIFIERS ELIMINATE GROUND LOOP PROBLEMS...RESCUE MICROVOLT SIGNALS FROM VOLTS OF NOISE

180 db DC, 130 db 60 cycle common mode rejection with balanced or unbalanced input ■ Input completely isolated from output ■ Input and output differential and floating ■ 5 microvolt stability for thousands of hours ■ 0.05% linearity, 0.1% gain stability ■ Gain of 10 to 1000 in five steps ■ >5 megohms input, <2 ohms output impedance ■ 10 volt at 10 ma output ■ 100 cycle bandwidth ■ Integral power supply

Ideal for thermocouple amplification, the Model 114A differential DC amplifier eliminates ground loops; allows the use of a common transducer power supply; drives grounded, ungrounded or balanced loads; permits longer cable runs; and can be used inverting or non-inverting. The 114A can be mounted in either single amplifier cabinets or six amplifier 19″ rack adapter modules. Prices: 114A – $875, six amplifier module – $295; single amplifier cabinet – $125.

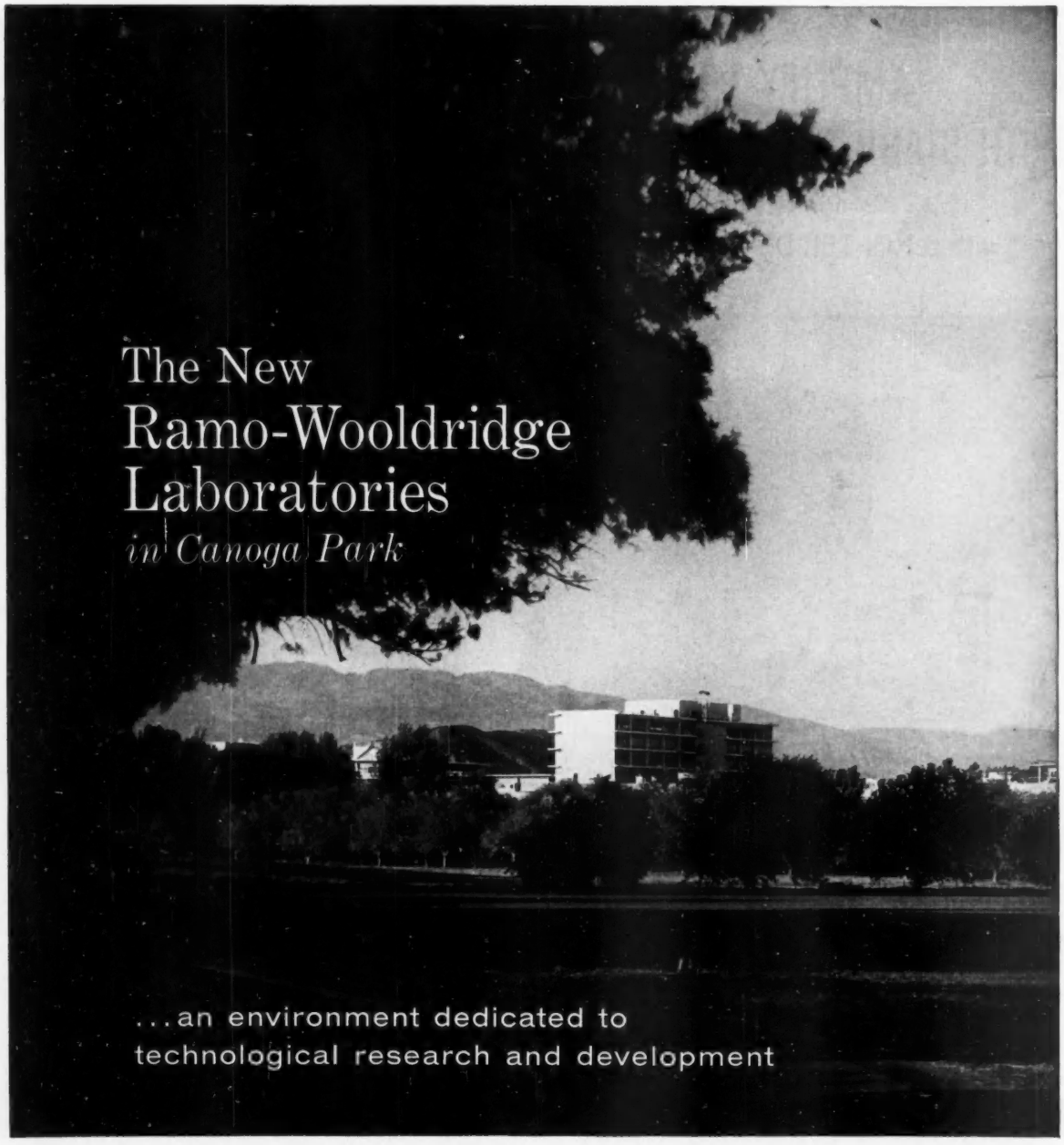
WIDEBAND, SINGLE ENDED DC AMPLIFIERS AMPLIFY DATA SIGNALS FROM DC TO 40 KC WITH 2 MICROVOLT STABILITY

±2 microvolt stability ■ <5 microvolt noise ■ 40 kc bandwidth ■ 100 KΩ input, <1 ohm output impedance ■ Gain of 20 to 1000 in ten steps with continuous 1 to 2 times variation of each step ■ ±45 V, ±40 ma output ■ 1.0% gain accuracy ■ 0.1% gain stability and linearity ■ Integral power supply

Millions of cumulative hours of operation have proved KIN TEL Model 111 series DC amplifiers to be the basic component for all data transmission, allowing simple, reliable measurement of strain, temperature and other phenomena. DC instrumentation systems – with their inherently greater accuracy, simplicity, and reliability than AC or carrier systems – are made entirely practical by the excellent dynamic performance, stability, and accuracy of KIN TEL DC amplifiers. Price: 111BF–$625, six amplifier module–$295, single amplifier cabinet – $125.

5725 Kearny Villa Road, San Diego 11, Calif.
Phone: BRowning 7-6700
Representatives in all major cities

KIN TEL
A DIVISION OF
COHU
ELECTRONICS, INC.



The new Ramo-Wooldridge Laboratories in Canoga Park, California, will provide an excellent environment for scientists and engineers engaged in technological research and development. Because of the high degree of scientific and engineering effort involved in Ramo-Wooldridge programs, technically trained people are assigned a more dominant role in the management of the organization than is customary.

The ninety-acre landscaped site, with modern buildings grouped around a central mall, contributes to the academic environment necessary for creative work. The new Laboratories will be the West Coast headquarters of Thompson Ramo Wooldridge Inc. as well as house the Ramo-Wooldridge division of TRW.

The Ramo-Wooldridge Laboratories are engaged in the broad fields of electronic systems technology, computers, and data processing. Outstanding opportunities exist for scientists and engineers.

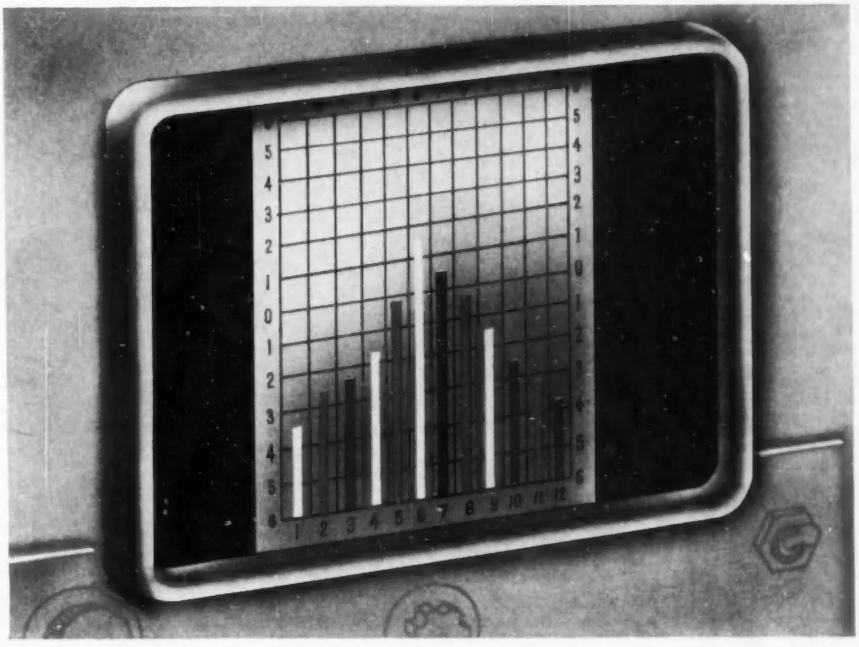
For specific information on current openings write to Mr. D. L. Pyke.

THE RAMO-WOOLDRIDGE LABORATORIES

8433 FALLBROOK AVENUE, CANOGA PARK, CALIFORNIA

From the home of *Planned Pioneering*

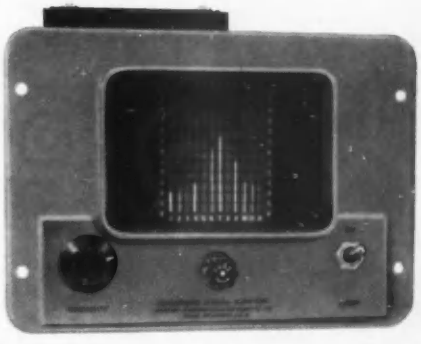
CENTURY COLORBAR
Visual Monitor Model 20E



A few of the typical applications of this EEZE Reading Colorbar Visual Monitor:

- Strain gage net work alignment
- Jet engine function analysis
- Magnetic tape editing
- Telemetry monitoring
- Presentation of test cell and test-stand parameters
- Observation of vibration modes
- In-flight monitoring of safety parameters
- Reactor control monitoring

Let us incorporate this instrument into your system applications



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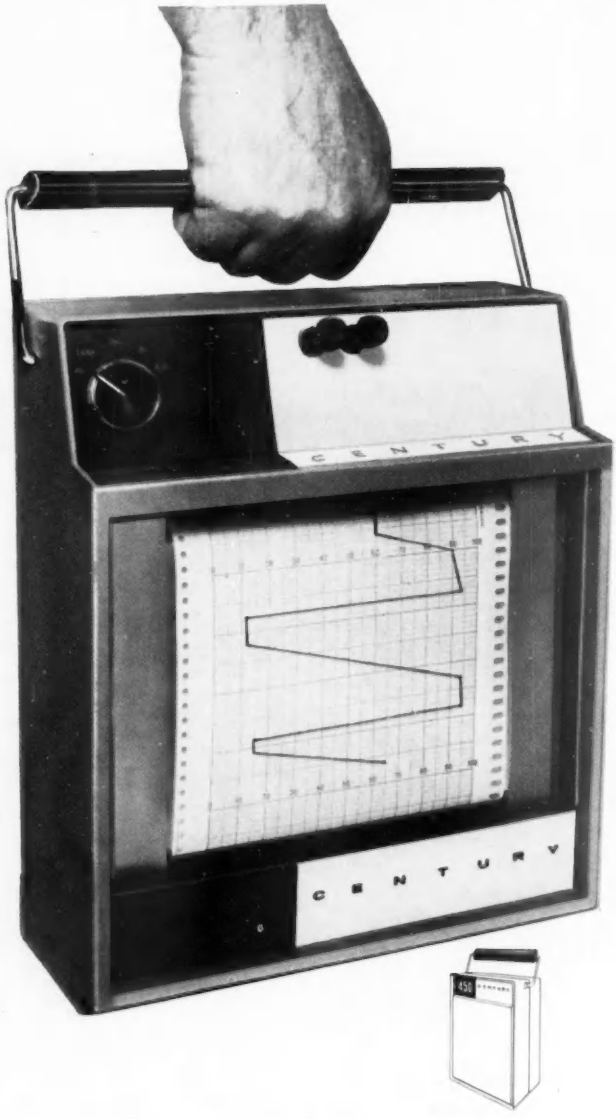
new



Portable Null-Balance Recorder with SELF CONTAINED POWER

THE CENTURY 450

For 2 channel recording Model 453 available at modest extra cost.

- 120 foot paper length — 200 hours recording time.
- Powered by standard "D" cells.
- Fully transistorized — Completely modular construction
- 100 millivolt full scale sensitivity
- Accuracy — better than ½% full scale.
- Tested for operation in rugged environments.
- Enclosed paper take-up spool.
- Available with many accessories;
  - — Plug-in pre-amplifier for 10 mv. full scale sensitivity.
  - — Transducer assemblies for conversion uses.
  - — Rechargeable batteries module.
- Field applications: Humidity, Temperature, Vibration, Acceleration, etc., recording.

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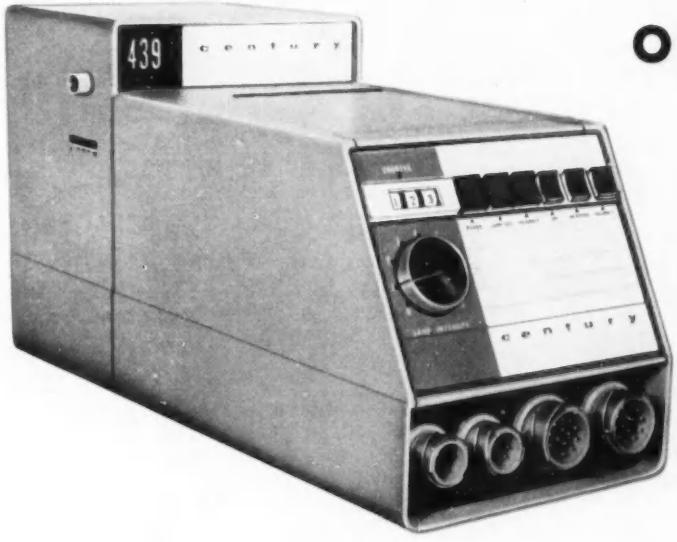
Exceptional opportunities for Transducer Designers — Contact Personnel Manager

From the home of *Planned Pioneering*

advanced design

THE CENTURY 439

VERSATILE RECORDING OSCILLOGRAPH



A small rugged oscillograph available with the following features:

- Data numbering
- Full width timing line
- 14 channels
- Daylight magazine — 100 ft. or 500 ft.
- Wide range of speeds
- Shock mount
- Overall size: 13¼" x 5¾" x 6⅞"

Send summary of application with inquiry.

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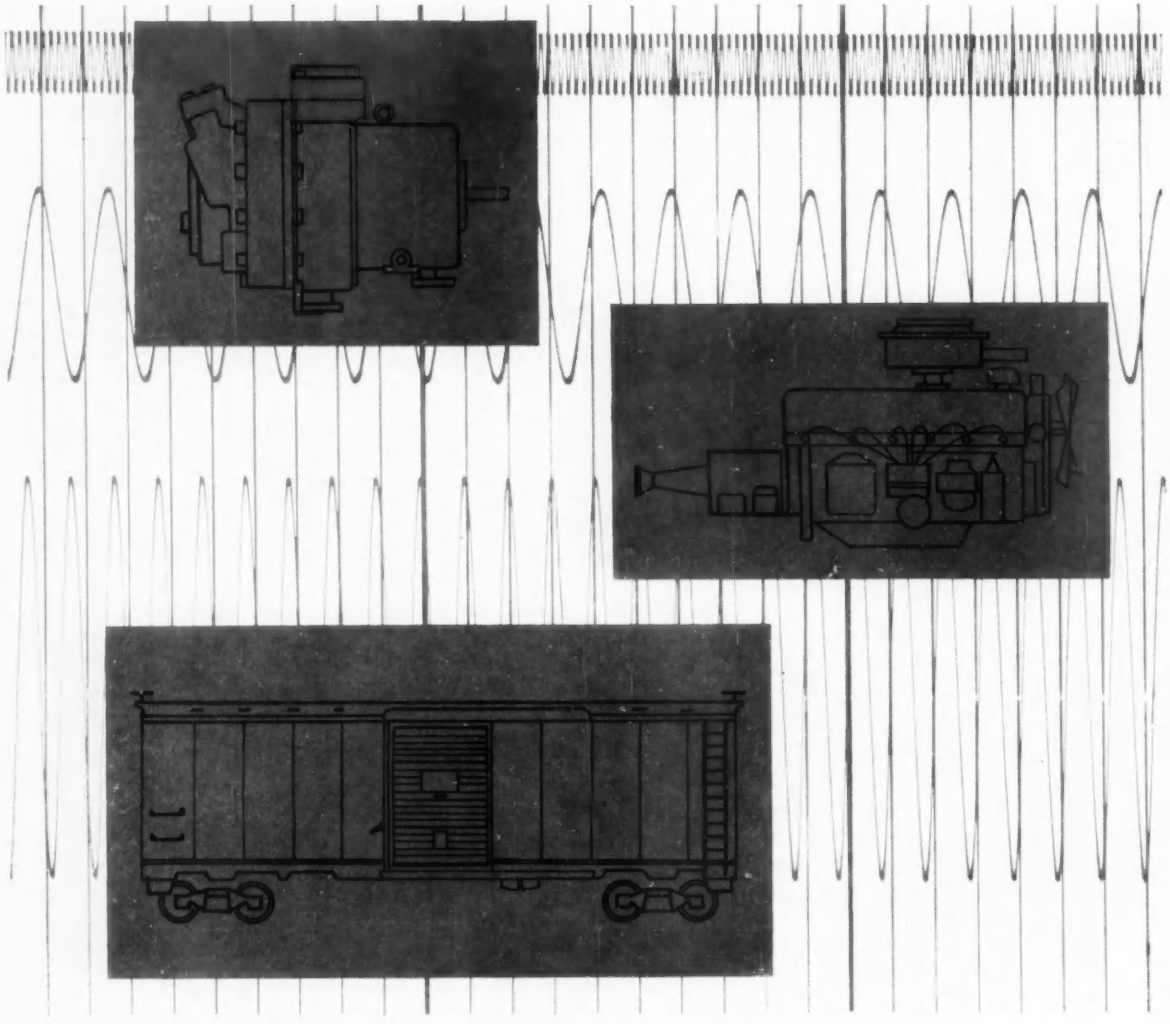

Lino-Writ 4 . . .
The Fastest, Toughest Photorecording Paper Available

Du Pont Lino-Writ 4 is the fastest oscillographic paper you can use . . . and the toughest. This member of Du Pont's full-line family of recording papers accommodates writing speeds up to 50,000 inches per second; safeguards your valuable records under severest usage; has exceptional exposing and processing latitude. It's easiest to read, too . . . and its 100% ultra thin rag-base saves vital storage space.

Whatever your oscillographic requirements, there's a Lino-Writ to fit your needs.

Lino Writ 1 for average test requirements at lower writing speeds. **Lino-Writ 2** for intermediate speed recording requirements. **Lino-Writ 3** for high-frequency recording without loss of detail.

For more information on our complete photorecording line, write: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, 2430-A Nemours, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, Toronto.

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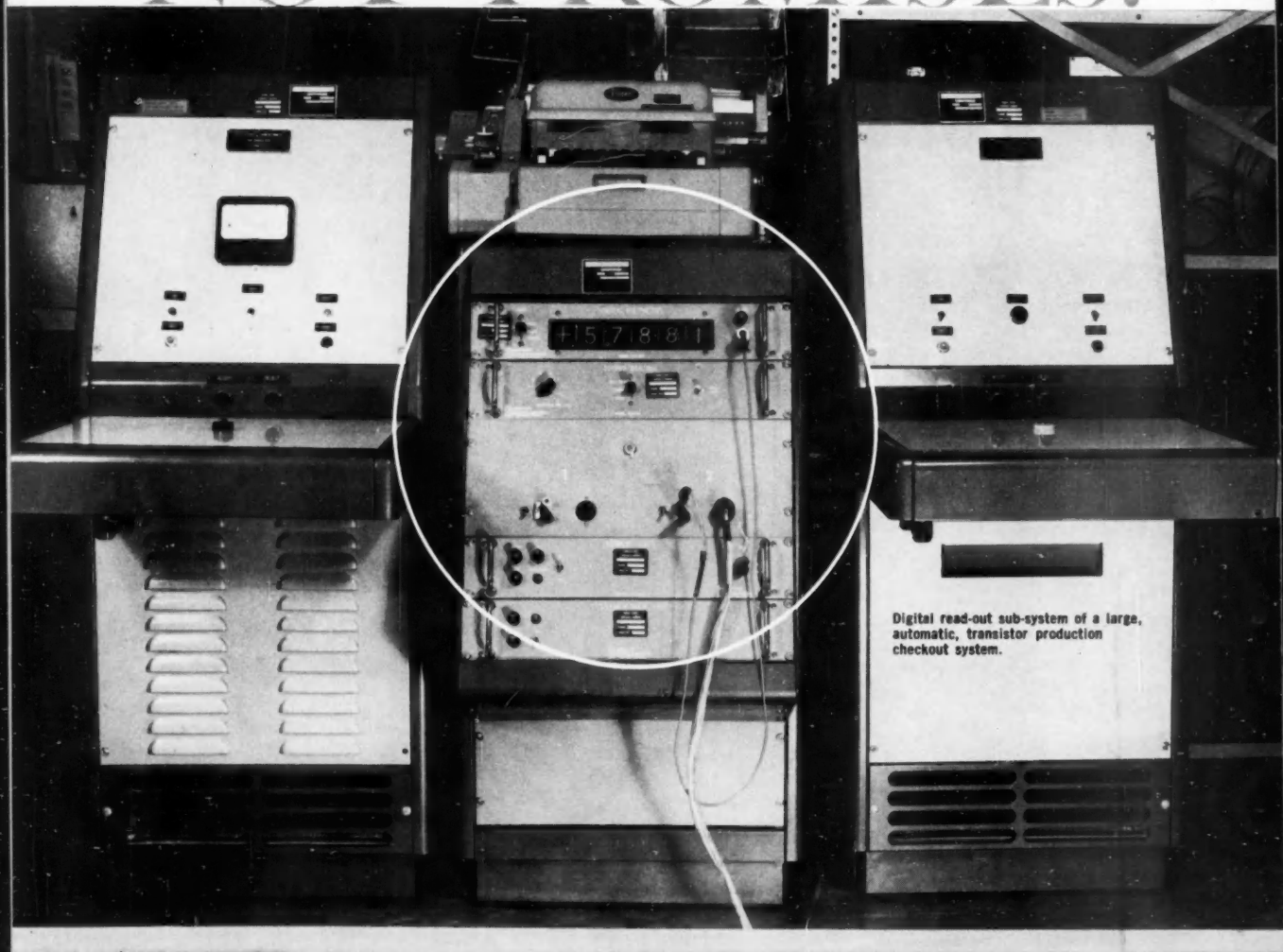
can meet your systems needs *now*

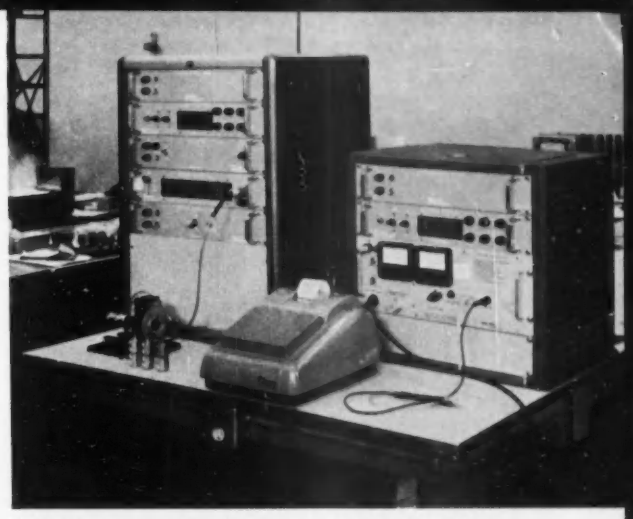
...with HARDWARE,

NOT PROMISES!



Digital read-out sub-system of a large, automatic, transistor production checkout system.

Sub-system for the ground support equipment on the B-58 **Hustler** program. Measures AC and DC single-ended voltages and ratios, and AC and DC differential voltages and transients. Chosen for its excellent operating characteristics under adverse environments.



Resistance measuring system — Used as a secondary standard to make accurate, resistance measurements required for checking linearity of multi-turn potentiometers.

Systems shown here are typical of more than 200 designed and built by EI and now in use. They range in complexity from data logging systems for automatic scanning, measurement and recording of data from multiple transducers... to high speed, automatic checkout systems for missile and aircraft... to systems for automating industrial processes.

Because of the EI modular design approach, many of these systems can be delivered on virtually an off-the-shelf basis, eliminating the long delivery times usually associated with system development. This approach also results in a low cost system because the modules are manufactured in large quantities. Cost is almost a linear function of performance capabilities desired.

you get MORE with EI systems!

MORE VERSATILITY

AC and DC voltages, AC and DC voltage ratios, ohmic resistances, capacitance, frequency, phase, inductance, time, or combinations of these basic input quantities can be accepted by the EI system.

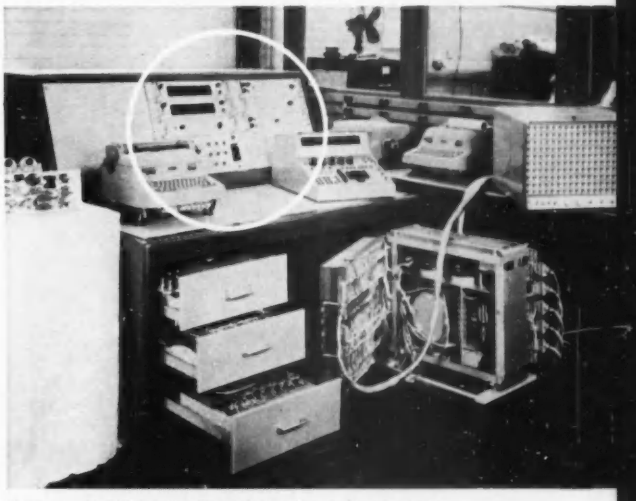
MORE RELIABILITY

Maximum use is made of solid-state and MIL-type components which are designed into conservatively-rated, field-proven circuits. All vendor-supplied parts are exhaustively tested and evaluated.

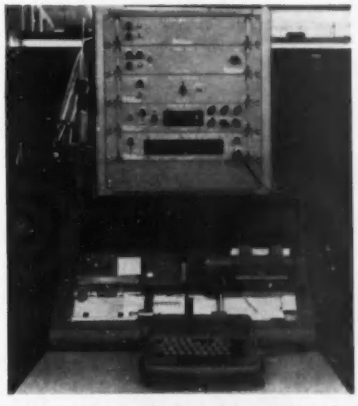
MORE FLEXIBILITY

Expansion of the EI system can be made by simply adding appropriate new modules. This approach eliminates new engineering development costs each time needs change; minimizes system obsolescence.

Why not talk over your digital system requirements with your EI Sales Engineer? His system experience will be a valuable help in solving your problem.



Multi-purpose digital measuring and recording system measures AC volts, DC volts, ohms and ratios. Prints and punches information for immediate reading by the operator and subsequent data reduction.



Resister scanning unit — Scans large numbers of resistors, measures values from 0.1% to 0.01% and records the information on punched cards. Operation is automatic and operates entirely unattended.

Electro Instruments, Inc.

CIRCLE 73 ON READER SERVICE CARD

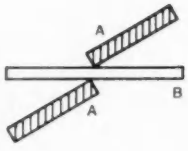
3540 AERO COURT, SAN DIEGO 11, CALIFORNIA

DIGITAL INSTRUMENTS FOR MEASURING AC/DC VOLTAGES, AC/DC RATIOS, RESISTANCE, CAPACITANCE, AND FREQUENCY • X-Y RECORDERS & ACCESSORIES • DC AMPLIFIERS

new north multi-contact multi-purpose connectors

These new, compact and highly efficient plug and receptacle type connectors provide maximum connection concentration in a limited space. They are designed for electronic applications in cable-to-cable, cable-to-fixture, fixture-to-fixture, and are available in 40, 60, 80 and 100 pin sizes.

A prongs of fork contact
B flat pin contact



Firm contact is assured by the unique torsion pressure principle in which beveled end flat blade male connectors seat into flat, fork shaped female blades placed at an angle to the male plugs—assuring double contact, providing minimum contact resistance.

The new design of the mounting hardware features a handy locking bolt for securing the plug to the receptacle and a removable cover with captive screw for rapid wiring or inspection. The permanent cable clamp is adjustable to accommodate varied cable sizes. All connectors are available with either solder or taper tab terminals.

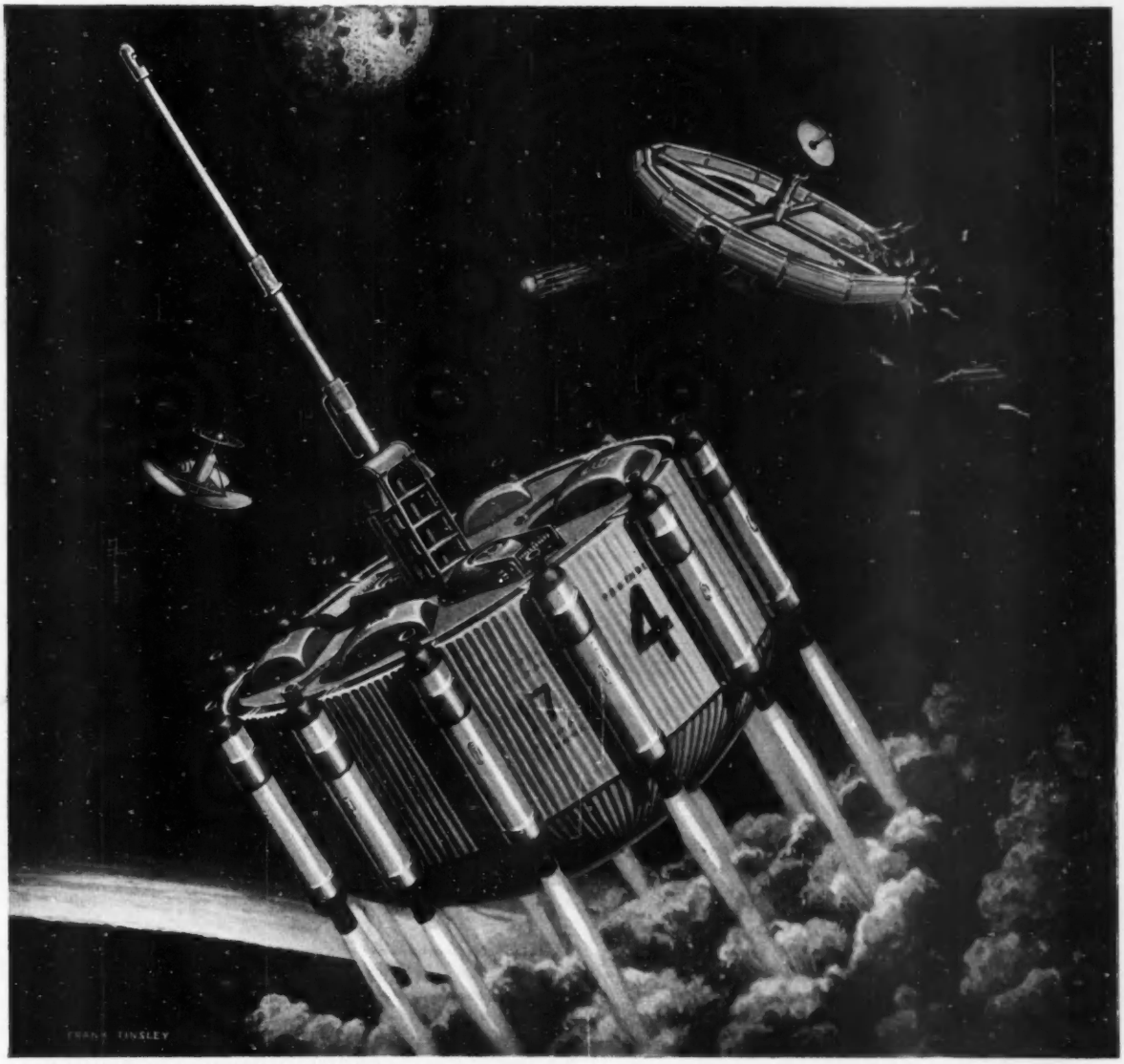
For full details, write

ELECTRONETICS DIVISION

NORTH ELECTRIC COMPANY

613 S. MARKET ST. *GALION, OHIO*

60-C-2



STEPS IN THE RACE TO OUTER SPACE

Escape In Space

The space-assembled super satellites of the future will periodically encounter disaster—collision, mechanical failure, military attack, or the long chance of being hit by a meteorite. When this happens, "life boats" like the one shown here will bring their crews safely back to earth.

Here is the operational sequence of an escape in space:

1. Crew members don pressure suits and strap themselves into decelleration beds within the pressure-intact unit.

2. At the "Abandon Ship" signal, low-power, RATO-type launching rockets blast the sealed capsule from the threatened station (upper right illustration).

3. Acting on orders from an astrogational computer, the retro-rockets check the capsule's speed and break it out of orbit. (Foreground. Note details of offset heat shielding, hatches, slow-down parachute covers.)

4. As the capsule enters the outer atmosphere, the heat shield protects the astronauts. The life boat's momentum slows even further, and the shield is jettisoned as it cools.

5. Four parachutes are released, acting as air brakes. After a computed interval, other chutes are released.

6. The capsule lands in a predetermined sea rescue area, and a ring of flotation bags inflate. A radio broadcasts the craft's location, and a bright sunshade serves as a visual and radar target for rescuers.

ARMA, now providing the inertial guidance system for the ATLAS ICBM and engaged in advanced research and development, is in the vanguard of the race to outer space. For this effort, ***ARMA*** needs scientists and engineers experienced in astronautics. ***ARMA***, Garden City, New York. A Division of American Bosch Arma Corporation.

AMERICAN BOSCH ARMA CORPORATION

MINICARD SELECTOR
(Illustration courtesy of Eastman Kodak Company)

RANDOM ACCESS MAGNETIC CORE MEMORY

3C ...
Solves problems with Special Purpose Digital Systems

Special purpose digital systems economically provide solutions to many complex problems in comparison, guidance, decision, evaluation, information storage and retrieval, sorting, computation, and similar needs. For speed and efficiency, a digital system cannot be equalled. Two examples are:

PROBLEM: *Wanted, a machine to make decisions involved in library-type operations (sorting, sequencing, selection) on single and multi-page documents photographically recorded on Eastman Kodak Minicard Film Records. These Film Records measure 16 mm. x 32 mm. Each one can hold up to 2730 bits of binary information, or up to 12 legal size pages with 294 bits of binary information. Binary information is photoelectrically scanned at a rate of 20 cards per second and the film records are sequenced where document pages extend to two or more cards.*

SOLUTION: A 3C special purpose digital system meets all requirements. The system incorporates T-PAC (1 megacycle) dynamic digital modules and magnetostrictive delay line serial memories. The manner and use of the 'question' material to select, sort and sequence, is determined by plugboard wiring and control panel switches. Even complex logical relationships between 'question' words and Minicard binary information (43 parallel bits per word in length) are specified on the plugboard. All operations are performed with the time-and-equipment-efficiency techniques characteristic of serial dynamic logic. In practice this system has proven highly successful.

PROBLEM: *Data-processing installation required to increase computation speed permitting on-line operation. A major portion of computation time is lost extracting roots in pressure-velocity conversions and correcting for non-linearity in other transducers.*

SOLUTION: 3C Modular Transistorized Random Access Magnetic Core Memory was installed to serve as a "linearizer" or table look-up. After calibration, data is stored in the memory (from magnetic or perforated tape, or other permanent source). A digital transducer signal, fed to the memory, acts as an address signal and the memory output produces the linearized signal. This allows linearization of any desired accuracy in a few microseconds, for direct use in a data reduction computer. Signals from one or several transducers can be linearized at rates well over 100,000 per second with a single 3C Memory.

SEE BOOTHS NO. 3308-3310
IRE SHOW

3C has designed and built a large number of special purpose digital systems during the last eight years. This experience is yours for the asking. Call us for consultation on your system requirements — proposals submitted on request.

COMPUTER CONTROL COMPANY, INC.

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BOSTON: CEdar 5-6220 • FRAM: TRinity 5-6185 • TWX FRAM 17
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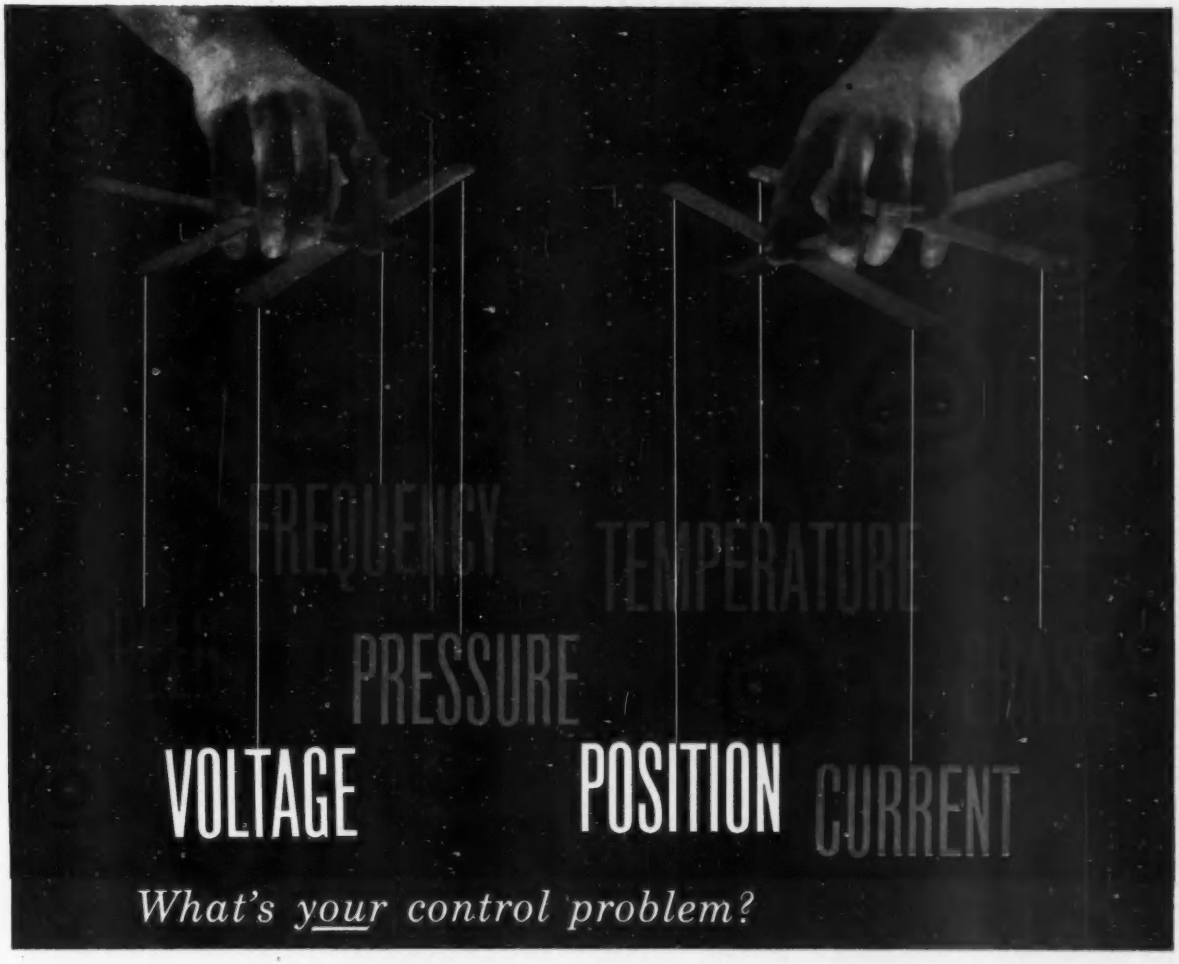
GRanite 8-0481 • BRadshaw 2-9135 • TWX W LA 6634



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CAN PROVIDE YOU
WITH CONTROL PRODUCTS
OR COMPLETE CONTROL SYSTEMS UTILIZING
MAGNETIC AMPLIFIERS AND SEMICONDUCTORS

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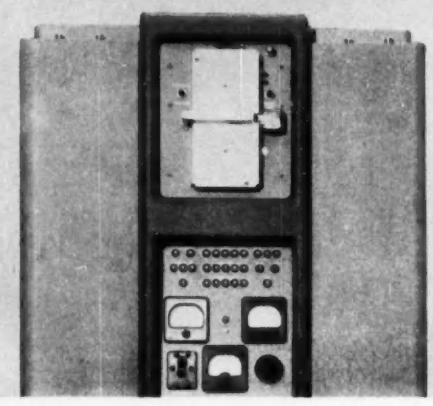
Designers and Manufacturers of SILICON AND SELENIUM RECTIFIERS · MAGNETIC AMPLIFIERS · MAGNETIC PARTICLE CLUTCHES-BRAKES · PHOTOELECTRIC CELLS

CIRCLE 77 ON READER SERVICE CARD 77

"Numerical control really pays off using the Bendix G-15 computer"



Joseph Strack

JOSEPH STRACK,
SENIOR TOOL ENGINEER
& PROCESSMAN
THE MARTIN COMPANY,
BALTIMORE DIVISION

The Martin Company uses a Bendix G-15 digital computer for producing punched tapes to operate numerically controlled milling machines. *"Parts are produced in one-fourth the time required by conventional milling,"* Strack writes, *"and comparing price with all other computers used for numerical control, the G-15 stands at the head of the list for economy."*

The G-15 manifests its economy in numerous ways. For example, it is exceptionally versatile. Over 250 are in use covering many facets of engineering, the sciences, business and industry. *"Although the G-15 was installed for a special purpose, its ease of use and various ways of programming have impressed me. It performs our specific task perfectly, and easily solves various mathematical problems."*

The G-15 can be expanded at will. Although the basic G-15 consists of the computer, an alphanumeric typewriter, a high-speed tape reader and tape punch, the user may add accessories to accommodate growing work loads. *"Added storage offered by magnetic tape units enables us to use combinations of routines interchangeably and fully automatically."* Punched card equipment, special high-speed paper tape readers and punches, a digital differential analyzer, a high-speed plotter, and other units are also available.

The G-15 pays off in ease of operation. *"Its simplicity enables the G-15 to be operated by personnel with no computer knowledge or background . . ."* In time savings, *"The G-15 has cut lead time tremendously, both in tooling and part manufacture."*

Write for detailed information.

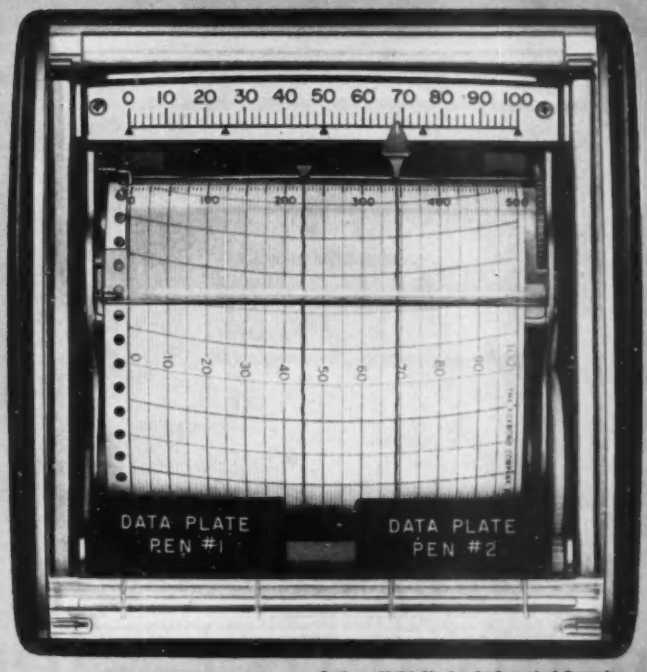
Bendix® Computer

DIVISION OF BENDIX AVIATION CORPORATION

LOS ANGELES 45, CALIFORNIA
DEPARTMENT W-19

another unit in Foxboro's **exclusive** 100% solid-state electronic Consotrol* system

Simplest most reliable electronic recorder yet!



Foxboro M/64 Electronic Consotrol Recorder

no amplifiers...no electrical adjustments

The precision and speed of electronics...*plus* the simplicity and reliability previously associated only with pneumatics. That's the new Foxboro M/64 electronic Consotrol recorder.

The M/64 uses a powerful magnetic torque motor to operate pens directly from a high-level 10-50 ma d-c signal. There's no amplification necessary—no slidewire or rebalancing unit. 4-inch vertical strip chart gives full-scale readability of records. One and two-pen models available for semi-hazardous or non-hazardous service.

The M/64 slides out of its housing like a drawer, so all servicing may be done from the front of the panel. Yet there is no interruption to recorder operation! What's more, zero, span, and linearity are all simple mechanical adjustments, so familiar to pneumatic instrument users.

Write today for Bulletin 21-10. It describes the new M/64 Recorder in detail, as well as the many other advanced instruments in Foxboro's complete 100% solid-state electronic control system. **The Foxboro Company, 853 Neponset Ave., Foxboro, Mass.**

*Reg. U.S. Pat. Off.

FOXBORO
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ELECTRONIC CONSOTROL INSTRUMENTATION / for every function in the control loop

FOR THE ENGINEER

who can't sleep nights

If you're losing sleep over a sticky problem in automatic control, AE can help—because AE has a reputation for making things *work* automatically.

It's not surprising, considering our unique experience in the design of circuits and components for automatic telephone exchanges.

What's more, AE relays and stepping switches are unique in their own right—because they're built to have substantially zero variation in operating characteristics *for life.*

As an example: the AE Class B Relay, illustrated, provides hundreds of millions of operations with unfailing contact reliability, and seldom needs maintenance. For this reason, it is probably the most inexpensive relay you can use where infallibility is an essential.

AE relays and stepping switches are custom-made to *your* specifications—and are also available wired and assembled into complete control units. And we're always glad to suggest specialized circuits that may cut your end costs.

Want more information? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois.

Also yours for the asking: Circular 1702-E, *Relays for Industry,* and a new 32-page booklet on *Basic Circuits.*

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GENERAL TELEPHONE & ELECTRONICS

WORKING PARTNERS

RCA 501 — SOUNDCRAFT INSTRUMENTATION TAPES

R-96

Big business depends more and more upon electronic data processing. For many corporations, the heart of their data reduction and storage operation will be the new RCA 501 Computer System. The crucial testing period of this new computer called for the most reliable of instrumentation tapes . . . Soundcraft. And, Soundcraft Tape proved to be the perfect working partner—not only in the testing, but afterward, in continuous working use.

In short, experience has proven that Soundcraft works best on leading computer systems, like the RCA 501. Let precision-made, trouble-free, error-free Soundcraft Instrumentation Tapes go to work for you. *Complete literature on request.*

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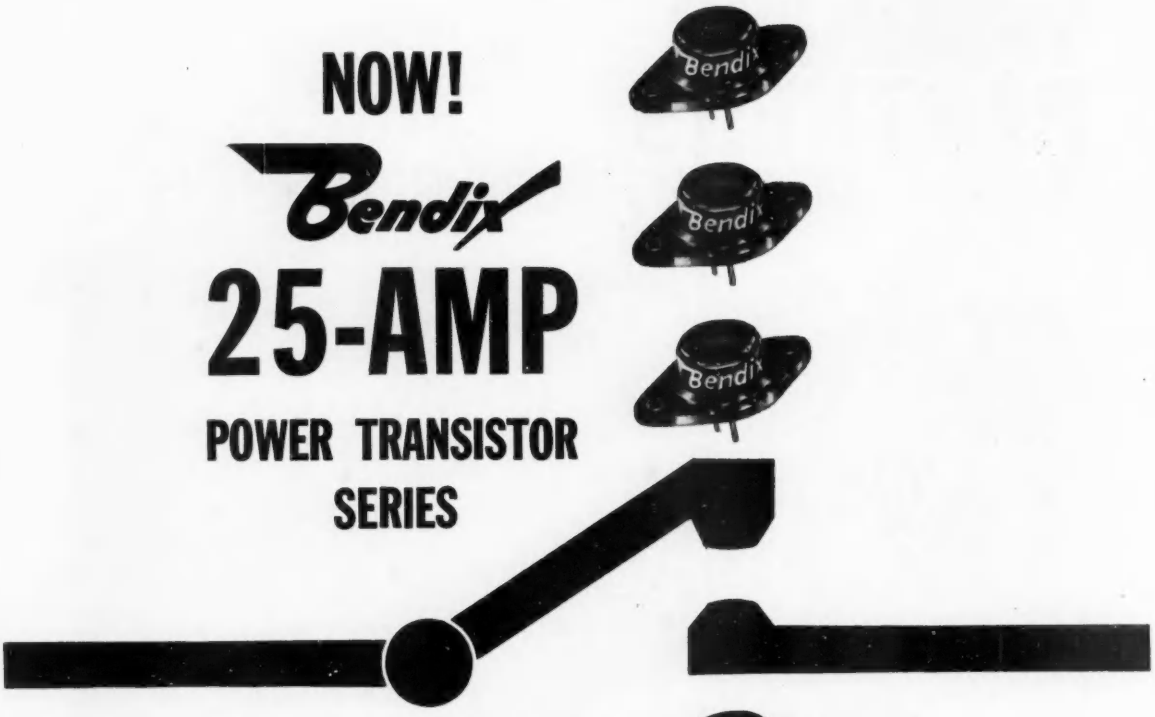
NOW!

Bendix 25-AMP POWER TRANSISTOR SERIES



Now in production by Bendix* are eight 25-ampere peak current power transistors capable of switching up to 1000 watts—and you can get immediate delivery on all eight types.

Newly improved in design, the transistors have a higher gain and flatter beta curve. The series is categorized in gain and voltage breakdown to provide optimum matching and to eliminate burn-out.

Current Gain hFE at Ic = 10 Adc	Maximum Voltage Rating			
	50 Vcb	60 Vcb	90 Vcb	100 Vcb
	30 Vce	40 Vce	70 Vce	80 Vce
20—60	2N1031	2N1031A	2N1031B	2N1031C
50—100	2N1032	2N1032A	2N1032B	2N1032C

Ask for complete details on this newly improved Bendix transistor series . . . and on the entire Bendix line of power transistors and power rectifiers. Write SEMICONDUCTOR PRODUCTS, BENDIX AVIATION CORPORATION, LONG BRANCH, NEW JERSEY, or the nearest sales office. *TRADEMARK

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205 E. 42nd Street, New York 17, New York
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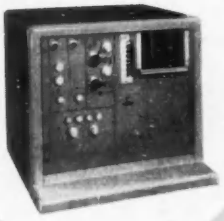
Bendix
AVIATION CORPORATION

The Offner Type R All Transistor Dynograph

provides greatest versatility

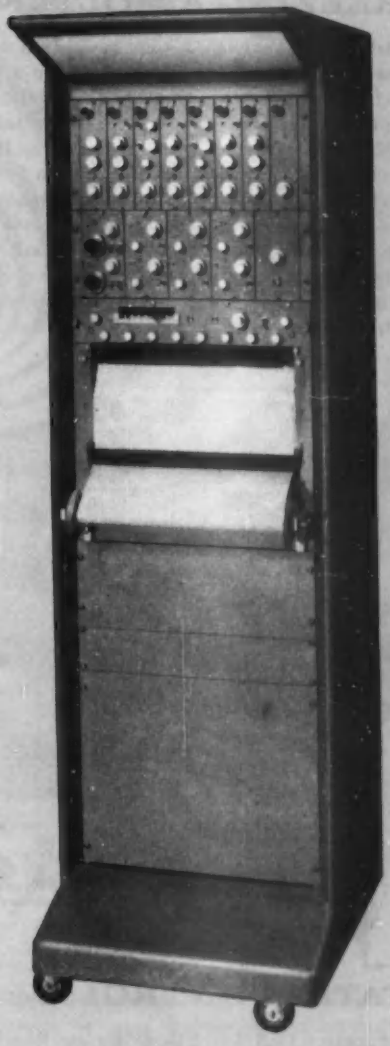


RP TWO CHANNEL
Compact, economical, convenient where only one or two channels are desired.

BMM/B CONSOLE
Features horizontal paper travel. Available as Type R or RC.

R SIXTEEN CHANNEL
Assemblies with 16 channels. 24 inch paper permits up to 24 channels on one inch centers.

RC DESK-TYPE CONSOLE
Medium gain assembly for computer write-out, telemetering, applications with input signal above 10 millivolts.



SEE IT AT THE I.R.E. SHOW BOOTH #3051

Write on your company letterhead for Bulletin 891, a 20 page, 2 color brochure giving you complete specifications, application data, etc.

VERSATILITY of assemblies—select the mounting best suited for your use.

VERSATILITY of application—one set of amplifiers covers all uses, microvolt to volts dc or ac, strain gages, reluctance gages, etc.

VERSATILITY of writing media—use ink, heat, electric interchangeably on one assembly—select the one most suited for the application.

The Offner Type R Dynograph Assembly is unmatched for sensitivity, accuracy, versatility—we invite you to compare it with any other high speed direct writing oscillograph.

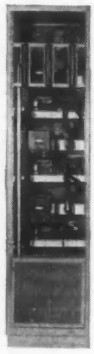
OFFNER ELECTRONICS INC.
3904 River Road, Schiller Park, Illinois (Suburb of Chicago)

CIRCLE 83 ON READER SERVICE CARD

JOURNAL OF APPLIED CONTROL DEVICES THAT NEVER WEAR OUT

For Control Engineers Who Are Wearing Out Before Their Time

FREEZING A MOLTEN WILL-O'-THE-WISP (to ±¼° at 2200°F)



Pittsburgh Plate Glass Company freezes molten glass temperatures at 2200°F to within ±¼° as it extrudes fiber glass so fine that 1700 miles of it weigh but one pound! How? PPG has selected CPM-1 Temperature Controllers made by Hagan Chemicals & Controls, Inc. The Hagan systems (over 200 of them have been ordered) not only set a new order of uniformity for glass fiber diameters, but are virtually wear-proof. They achieve this doubly profitable result by use of static control elements: there are no moving parts, and only one vacuum tube device in the entire system! An integral part of the CPM-1 unit is a CONTROL Proportioning Reactor with six control windings. It receives a proportional signal, a reset signal and a rate signal, and provides both current limiting and manual control. *"Rugged and able to handle multiple signals, yes," said Hagan engineers, "but what about sensitivity?" When we showed them the proportioning reactor's 2-milliampere windings, there were no more questions. However, we'll be happy to answer any you may have.*

Figure 1. Hagan CPM-1 Temperature Controllers. Square Boxes are CONTROL Proportioning Reactors.

ON YOUR BOBBIN, RESET, GO!

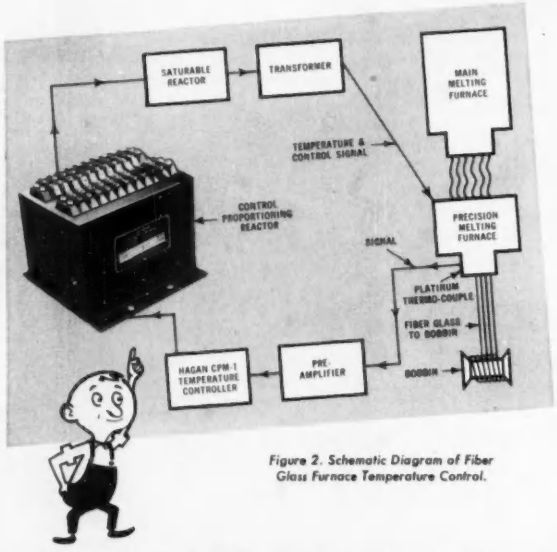


Figure 2. Schematic Diagram of Fiber Glass Furnace Temperature Control.

Fiber glass is pulled through a die in the bottom of a "bath tub" of molten glass at more than 3 miles per minute. It is wound on a bobbin, and when a "package" is completed, the operator has 15 seconds to change bobbins and restart the operation. There is as much as a 15° temperature upset in the system, yet when the winder restarts, the controller must reset the temperature at 2200° within ±¼° in the allotted 15 seconds. The CONTROL reactor puts out 100 watts at 80 volts, sufficient power to drive the saturable reactor ahead of it, and is at the instant beck and call of rapid and minute changes in signal. The response of the overall Hagan system is better than 0.1 seconds at full output. *When the first tests were run, accuracy of control was found to be even better than the ±¼° anticipated. Should you wish to learn more about these satisfactions with static control via our proportioning reactors, we'll be happy to answer your request for intimate details.*

STATIC CONTROL: (flexible and standard)

The function CONTROL Proportioning Reactors play in a system (the Hagan Temperature Controller is a telling example) is unique. The designer—for process control, for machine tool control, for assembly line control, for almost any control—can feed a variety of input signals into several isolated control windings in each proportioning reactor, and sum them to provide an amplified control signal. The reactor's figure of merit (ratio of volt-ampere amplification to time of response) is exceptional. It is as high as 1,500 for an N_C^2/R_C of 1,800. Thus, there is both power and sensitivity for the designer who works with static control. *Want to know who else among the nation's leaders have joined production-smart Pittsburgh Plate Glass in the swing to static control? We'll be happy to tell you—and to help with your static control ideas.*

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the science of

rotation...

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TACHOMETER
TYPE SJ7HLZ7-4

High Performance
plus Low Tachometer Power

This small motor tachometer features high torque output per watt input and excellent signal to noise ratio. It is an ideal choice for those applications where space is limited yet the high performance and reliability of a precision damping, motor generator is required. Other BuOrd Size 8 motors, tachometers and gearhead units are available, built to E.A.D.'s high standards as well as to meet specific customer requirements.

TYPICAL CHARACTERISTICS

GENERAL: Frequency, 400 c.p.s. • Rotor Inertia, 1.2 gm.cm.^{2} • Torque at Stall, 0.34 oz. in. • Oper. Temp. Range, −55° to 150° C • Weight, 2.8 oz.

MOTOR: Motor Voltage (fixed & control phases), 26 • Power (Stall), 2.5 Watts

GENERATOR: Excitation, 26v, 400 c.p.s. • Power (Stall), 1.5 Watts • Output at 0 RPM, 0.010 V.R.M.S. • Output Voltage, 250 Mv/1000 RPM • Signal to Null Ratio, 25/1 at 1000 RPM

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Eastern Air Devices' contribution to systems design is the science of rotation. This concept represents the basic engineering and production approach of a company whose products are specified everywhere to meet the critical performance and reliability requirements of today's systems . . . tomorrow's designs. Eastern Air Devices' product line — the most complete and diversified in the industry today — and the company's new developments in bearing life, high temperature insulations, oxidation protection . . . reflect the technical confidence developed during 18 years in the application of the many sciences of rotation. At Eastern Air Devices you are assured of a 1960 scientific approach to the application of rotating electrical components . . . whether you select from the standard line or order special designs.

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INERTIALLY DAMPED SERVO MOTORS • TORQUE MOTORS • FANS
DAMPING MOTOR TACHOMETERS • GEAR MOTORS • ALTERNATORS

A GOOD RUN FOR YOUR MONEY—

New "SCOTCH" BRAND Heavy Duty Tapes offer exceptional life, low rub-off, good resolution

HAVE PROBLEMS OF TAPE-LIFE, rub-off and resolution? To cure your headaches in applications that subject magnetic tape to high speeds, pressures, temperatures and low humidity, "SCOTCH" BRAND now prescribes two new tapes—Heavy Duty Tapes 198 and 199. They offer plus-performance in a wide variety of temperature and humidity conditions.

Take the matter of wear, for instance. Field tests show that "SCOTCH" BRAND Heavy Duty Tapes wear five times longer than standard tapes—yet they maintain good resolution and freedom from drop-outs over this long haul. Two factors are decisive in this performance—resistance to rub-off and resistance to high temperatures.

Ordinary tapes age fast if the temperature climbs or the relative humidity drops sharply. The binder softens, allowing the oxides to rub off on those costly and sensitive heads.. Further, as an electrostatic charge builds with each pass, stray contaminants are attracted to the tape—and the tape starts to cling to the equipment. In each case—your drop-out count mounts.

Not so with "SCOTCH" BRAND Heavy Duty Tapes. They boast an extra tough binder system similar to that used in "SCOTCH" BRAND Video Tape, which after two years is still the only video tape in commercial use. The heavy duty binder system anchors the oxides firmly to the polyester base in a way that resists very high temperatures—minimizing rub-off. Moreover, Heavy Duty Tapes have a conductivity nearly 1000 times greater than conventional tapes, allowing static charge to drain off. Result? Clean, smooth runs with good resolution—a good run for your money.

Performance of this kind is easy to promise—much harder to deliver. And only experienced "SCOTCH" BRAND technology has such a record of delivering the right tape for every application in data acquisition, reduction or control programming.

Check all the tapes in the "SCOTCH" BRAND line. High Resolution Tapes 158 and 159 pack more bits per inch, offer extra play time. High Output Tape 128 gives top output in low frequencies, even in temperature extremes. Sandwich Tapes 188 and 189 drastically cut head-wear, eliminate oxide rub-off, and wear 10 times longer than ordinary tapes. Standard Tapes 108 and 109 remain the standard of instrumentation.

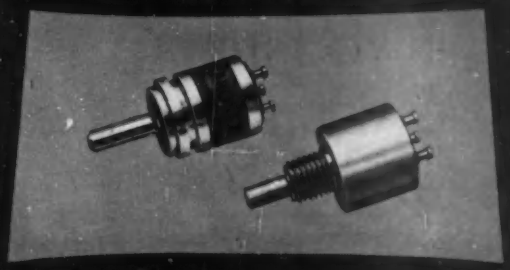
Your 3M Representative is close at hand in all major cities—a convenient source of supply and information. For details consult him or write Magnetic Products Div., 3M Co., St. Paul 6, Minn.

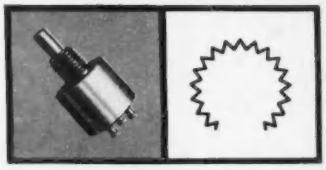
REG. U.S. PAT. OFF.
SCOTCH BRAND MAGNETIC TAPE
FOR INSTRUMENTATION

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

PERFORMANCE-PACKED 1/2" PRECISION POTENTIOMETERS

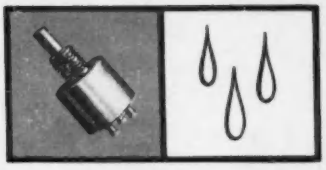
CLAROSTAT SERIES 57





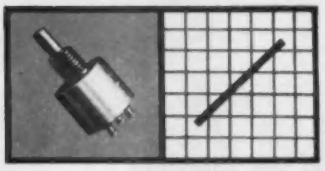
UP TO 50K OHMS

Resistance range: 50 ohms to 50,000 ohms ± 5%. 1.5 watts @ 40°C.



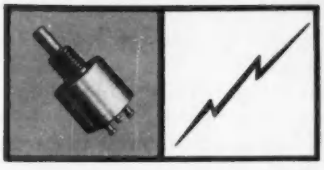
COMPLETELY SEALED

Meets and exceeds military moisture and humidity requirements.



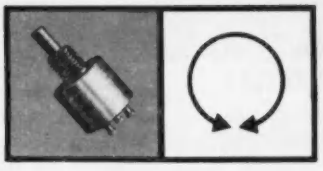
± 2% INDEPENDENT LINEARITY

± 2% deviation for actual angular displacements. Tops for ½" diameter potentiometers.



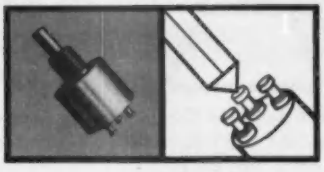
MINIMUM ELECTRICAL LEAKAGE

High dielectric materials employed throughout with nickel-silver body.



RESOLUTION

.08% resolution permits extreme accuracy in read-out and setting.



MECHANICAL/WELD TERMINATIONS

Windings terminated with tapered-pins and electronic weld. Terminals molded in place.

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CLAROSTAT MFG. CO., INC.

DOVER, NEW HAMPSHIRE

In Canada: CANADIAN MARCONI CO., LTD., Toronto 17, Ont.

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IMMEDIATE DELIVERY!

Phone your local Clarostat Industrial Distributor for popular, standard Series 57 or military style RV-4 units...for fast delivery from local stock.

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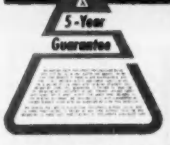

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Each Lambda Power Supply carries a written guarantee that warrants full performance to specified ratings for five full years.

Lambda, alone, offers this unprecedented guarantee because Lambda specializes in the design and manufacture of just one product — power supplies.

Each unit is built from the ground up to rigid quality standards in a modern, completely integrated plant. Nothing is overlooked to provide you with the finest performance. When you buy a Lambda Power Supply, you are assured of a unit that is conservatively rated—a unit designed to provide continuous-duty service at all specified loads and ratings.

Lambda power supplies are available in a wide range of rack, portable and bench models for laboratory and production service. Of particular interest to electronic designers are:

L-T Transistor-Regulated Series ..... **0-1 and 0-2 AMP, 0-32 VDC**
Com-Pak Tube Regulated Series ..... **200-400-800-1500 MA**
0-200, 125-325, 325-525 VDC

Write for free 32-page catalog for complete specifications, dimensions, performance ratings and prices on Lambda's full line of tube-regulated and transistorized power supplies.

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Watch for Lambda's exciting new solid-state power supply developments.
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How RECOMP handles numbers that could circle the world 2½ times

RECOMP can handle a floating point number greater than four billion factorial... or larger than the figure 1 followed by 41 billion zeros. Typewritten, the number would stretch around the world two-and-one-half times.

RECOMP is a low-cost, general purpose, digital computer—the original solid state computer with *proven reliability*. Its built-in floating point arithmetic and square root instructions come as a standard feature among RECOMP'S 49 commands... at no extra cost.

Easy to operate, easy to program... RECOMP has a storage capacity of over 8000 instructions, simplified coding, fingertip control console with digital readout panel, and a high-speed photoelectric tape reader.

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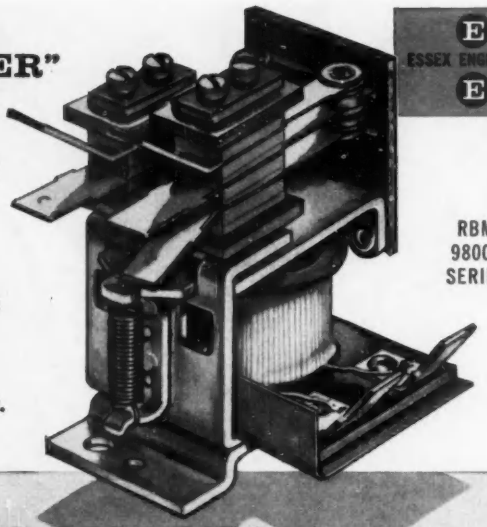
SMASH THE "DESIGN BARRIER" AND STILL LOWER YOUR FINISHED PRODUCT COST!

Since the basic relay and its many contact forms, ratings, and terminal variations are regular production items at RBM, design bottlenecks can be shattered. RBM has "CUSTOMERIZED" these relays to fulfill almost every conceivable requirement. This vast background of application engineering can serve you with design shortcuts . . . lower your "finished product" cost. Ask your RBM product application engineer.



RBM 98000 SERIES

CHECK THE FEATURES OF THIS RBM AC OR DC GENERAL PURPOSE RELAY

MANY ARE LISTED BY U/L FILE NOS. E 12139 OR E22381

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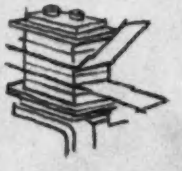
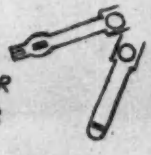
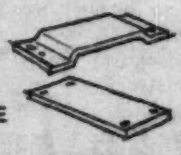


DEPENDABLE CROSS-BAR CONTACTS AVAILABLE FOR LOW VOLTAGE AND/OR LOW CURRENT CIRCUITS



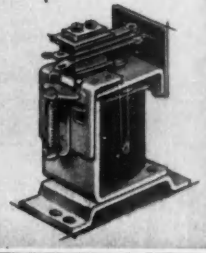
SIMPLIFIED MAGNET FRAME AND ARMATURE ASSEMBLY PROVIDES EFFICIENT, POSITIVE ACTION

VARIETY OF MOUNTINGS AVAILABLE



OTHER FEATURES	A.C. 98700 TYPE	D.C. 98600 TYPE
• MAX. COIL VOLTAGE	230AC	115 DC
• MAX. COIL RES. IN OHMS	—	20000
• MAX. COIL WATTS OR VOLT AMPS.	9.0 V.A. INRUSH 6.5 V.A. SEALED	4.0 W.
• MAX. CONTACT FORM WITH RATED CURRENT AT 32 V. DC OR 115 V. AC (NON-INDUCTIVE LOAD)	2PDT 15 AMPS. 4PDT 6 AMPS. 6PDT 3 AMPS.	2PDT 15AMPS. 4PDT 6AMPS. 6PDT 3AMPS.
• APPROX. WEIGHT	4.1 OZ.	4.1 OZ.

ALSO AVAILABLE IN 97000 SERIES PROVIDING ADDITIONAL COIL POWER... GREATER SENSITIVITY



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RBM Controls Division

ESSEX WIRE CORPORATION, LOGANSPORT, INDIANA

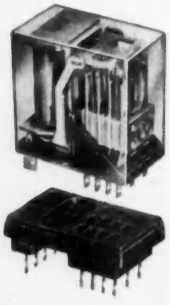
Factories Located at North Manchester and Logansport, Indiana

ALLIED CONTROL'S

NEW LINE OF

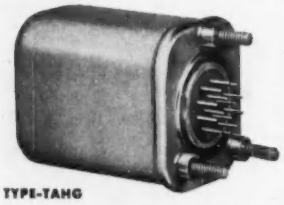
Sub-Miniature Telephone Type Relays

Now being manufactured entirely in the U.S.A., not only in its original West German design previously sold in this country by Allied Control Company, Inc. under an agreement with Siemens & Halske Company A.G. Germany but with variations to meet American requirements as well.



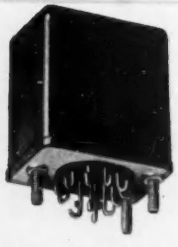
TYPE-T-154

H-1 3/16 • W-47/64 • L-1 11/64



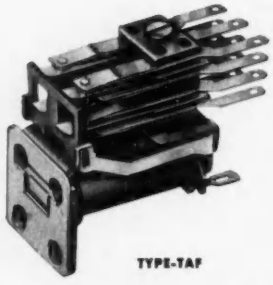
TYPE-TAHG

H-2 3/16 • W-1 7/16 • L-1 5/8



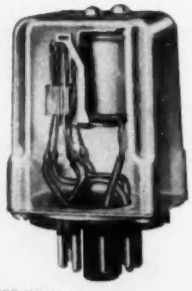
TYPE-TAH

H-1 19/32 • W-61/64 • L-1 11/32



TYPE-TAF

H-1 17/64 • W-41/64 • L-1 5/16



TYPE-TADO

H-2 • W-1 13/32 • L-1 13/32

PERFORMANCE CHARACTERISTICS

Contact Arrangement
Up to 12 springs maximum form A, B or C

Contact Rating
2 amperes resistive or 1 ampere inductive at 29 volts d-c or 115 volts a-c
Low level or 5 ampere contacts available on request

Standard Coil Voltages
Suitable coil resistances can be supplied for operation at any voltage within the range of 0.5 to 130 volts d-c

Coil Power
Nominal: 700 milliwatts
Minimum Operate Power: 125 to 300 milliwatts depending on application, contact arrangement and coil resistance.

Timing at Nominal Voltage
Operate time: 15 milliseconds maximum
Release time: 5.0 milliseconds maximum

Vibration
10-55 cps at .062 inch double amplitude
55-500 cps at a constant 10g

Shock: 25g operational

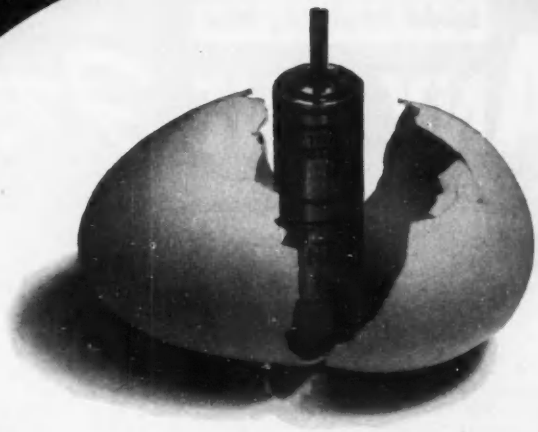
Enclosure
Open, dust cover or hermetically sealed

Weight
Open type 1.0 ounce maximum
Sealed type 2.0 ounces maximum

ALLIED CONTROL

ALLIED CONTROL COMPANY, INC., 2 EAST END AVENUE, NEW YORK 21, NEW YORK

size 5 motor generator—JUST OUT!



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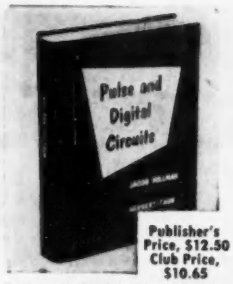

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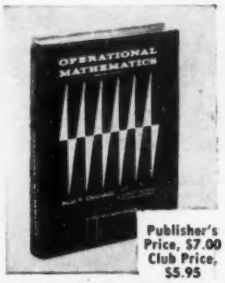

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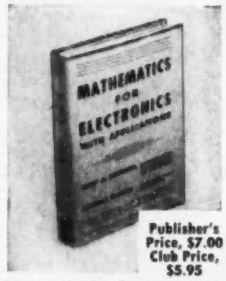

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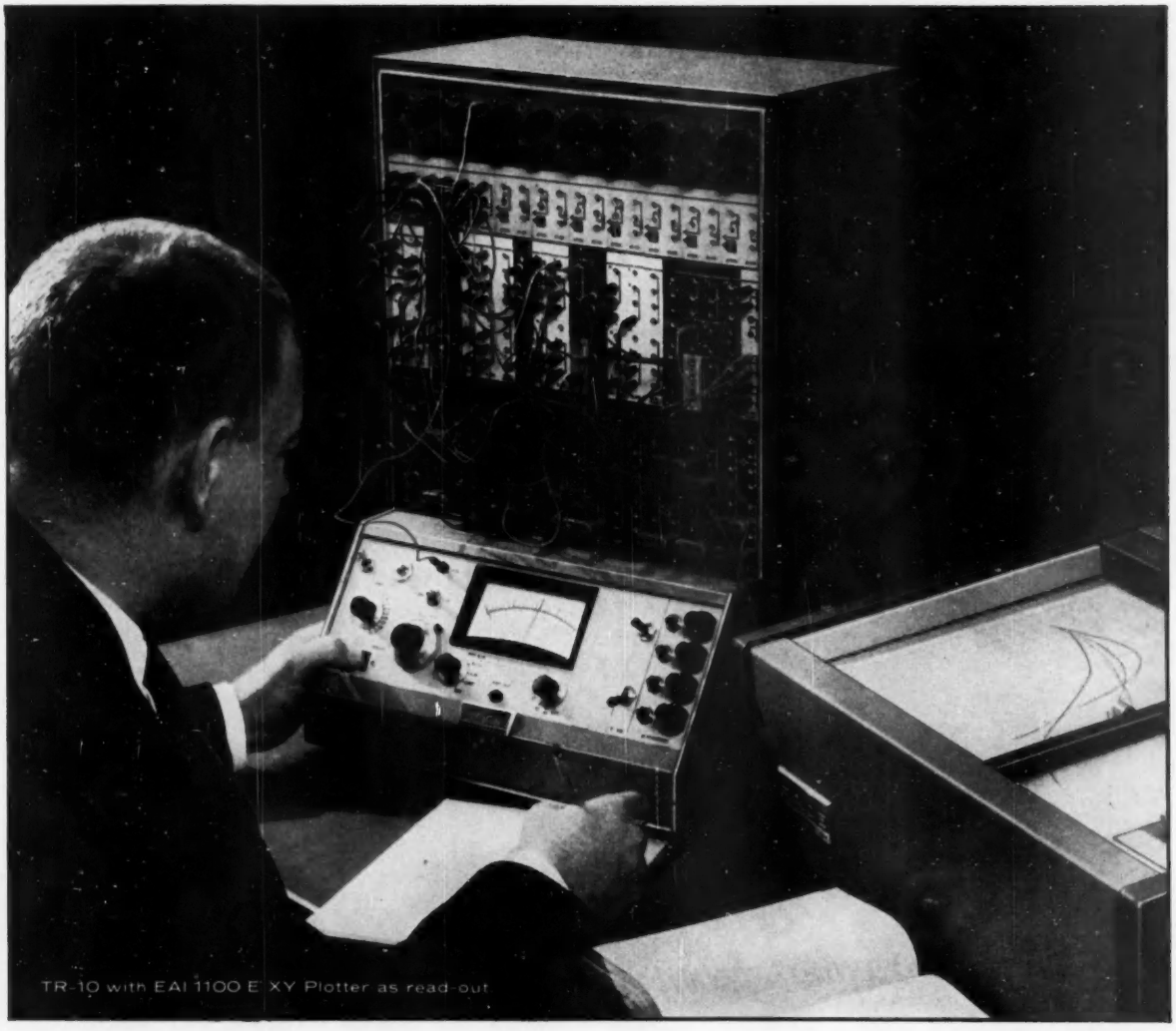

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PACE® TR-10 Eliminates Drudgery—Gives New Insight Into Engineering Problems

This compact unit, 15" x 16" by 24" high, is powered by 115 volts AC and can provide day-in day-out instant solution of your most vexing engineering problems. Even if you have never seen a computer before, you can learn to operate the TR-10 as easily as you learned to use a slide rule.

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The same quality workmanship and design that has made Electronic Associates the world's leading producer of precision general purpose analog computers will be found in this new unit. Accuracy to ±.1 per cent. Modular construction allows you to select varying quantities of the following computing functions: summation, integration, multiplication or division, function generation, parameter adjustment, logical comparison.

For complete engineering data, write for Bulletin CC-822A.

See TR-10 in operation, New York IRE booths 3712-18.

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Long Branch, New Jersey

Dc Drives Set for New Gains

Manufacturers of dc adjustable speed drives—motors and the controls that go with them—are happily expecting another new sales peak in 1960. Increased spending for plant improvement, bigger control content, and servomotors that are more competitive with hydraulic equipment are among the influences aiding the climb. And the industry will do this better business without yet calling upon their trump card—the silicon controlled rectifier—with which manufacturers soon hope to make drives more attractive to the users from the aspects of cost, reliability, and size.

Sales leap 30 percent

The Big Three of the full-line companies, General Electric, Reliance, and Westinghouse, expect the 1960 dollar volume of sales to exceed that of 1959 by 20 to 30 percent. And surprisingly enough, 1959 itself was a good year which saw the dc drive business recover almost fully from the 1958 slump. NEMA puts 1959 orders for packaged drives alone at $38 million covering 30,000 units. But NEMA, which just started collecting statistics on dc adjustable-speed drives in recent years, admits that this figure gives only a clue to the true size of the field. The total given accounts merely for the sale of standard off-the-shelf packages. The sales of the big "engineered drives" which account for at least half of the dc business are not reported by NEMA members.

If their estimates are correct, the drive manufacturers can boast of one of the most spectacular growth records in American industry. In 1955, sales took an abrupt jump and—except for the 1958 slowdown—have continued on the upgrade ever since. At about that time, dc adjustable speed drives were not regarded as particularly big business, certainly not in the same class as such standard motor types as the fractional and squirrel-cage types which literally pour off the production lines around the clock.

General Electric and Westinghouse, who are tough to beat in the standard motor field, did not at first have integrated dc departments. Within each company, dc production, design, and marketing facilities were dispersed among several independent groups. This lack of integration left the door open for "specialty" manufacturers to move in. Reliance adopted the dc line as its own private specialty and was in an ideal position to prosper as the demand for adjustable speed equipment swelled. And prosper it did, riding the tail of the dc comet to "big company" status. General Electric and Westinghouse now have integrated dc departments to serve the growing needs of users of adjustable-speed drives. As testimony to its confidence in the dc field, GE spent $27 million about five years ago to pull all of its dc activities under one roof at Erie, Pa. In addition to the Big Three, a great number of smaller firms are also actively producing limited and specialty lines of dc equipment.

Kinds of drives

A dc adjustable speed drive consists basically of a motor and a source of controlled dc power. There are three distinct kinds of drives which can be classified by the nature of the power supply: tube-type electronic, static (semiconductor rectifier plus magnetic amplifier control), and the Ward Leonard system. Each type has its own particular area of

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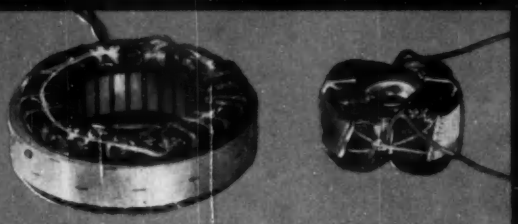


6′ max. error spread Synchro for Gyro Pick-Off

The SG-17- and ST-17- type pancake synchros (SG-18- and ST-18- with housings) are our most standard line for gyro pick-off applications.

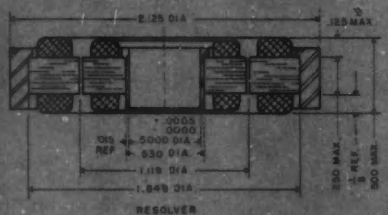
These units have been manufactured in large quantity and are readily available for prototype breadboarding. The high accuracies shown on the left are obtainable in standard 26v or 115v units.

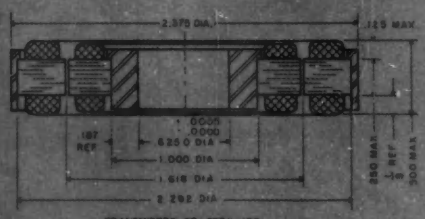
Custom Designed Pancakes

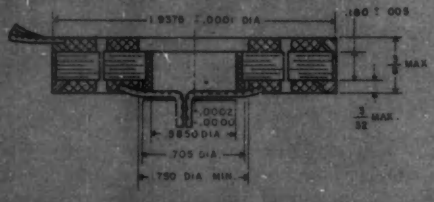
CPPC has developed a number of special pancakes (drawings below) with relatively large bores and narrow stack heights.

Means have been devised to minimize error due to clamping pressures on these thin units.

Special accuracies have been maintained where required. Let us know your needs.

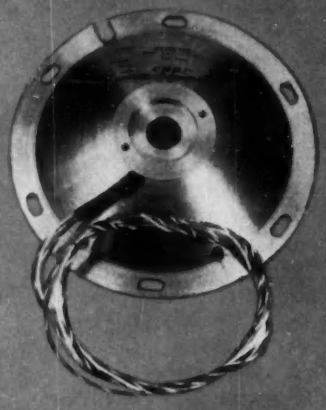






Pancake Resolver for Gimbal Mounting

Clifton Precision produces special pancake resolvers for direct gimbal mounting. They were developed for use in cascaded amplifierless resolver systems and have been trimmed for 1CK input impedance, 0° phase shift and a constant transformation ratio, with temperature, at 900cy. Accuracies of 4′, perpendicularities of 3′ and nulls of 1mv/v of output or less can be held.



Special techniques maintain concentricity between rotor and stator — thus reducing difficulties commonly encountered in gimbal mountings.

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application as determined by factors like cost, reliability, environment, response, and gain characteristics.

For years the split-up in usage among the three has remained fairly constant. But onlookers are expecting some upheaval in this situation as a result of the development of the highly touted silicon controlled rectifier, which appears to be remarkably suitable as a source of easily adjustable dc power. Surprisingly, none of the manufacturers will admit that this upheaval is at all close to happening although each claims to have experimental controlled rectifier units out on field test. And come what may, the venerable Ward Leonard system is assured of continuing undiminished popularity because of its unique regenerative braking capability and resistance to overload damage.

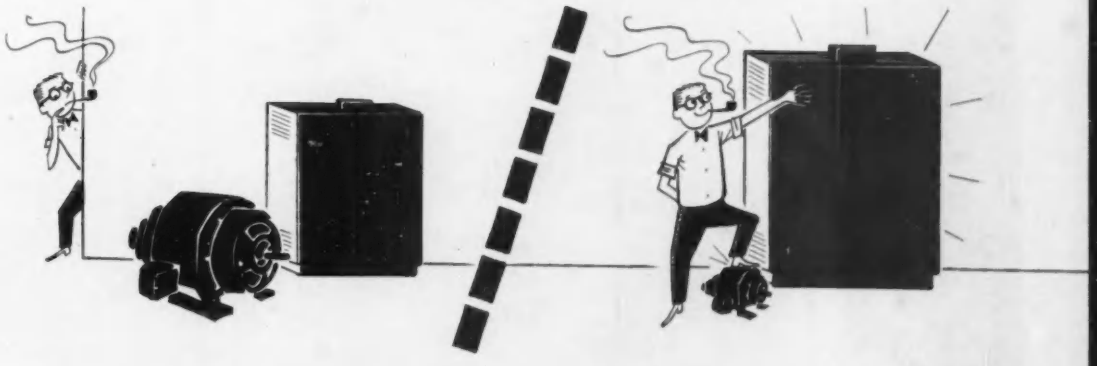
Systems business

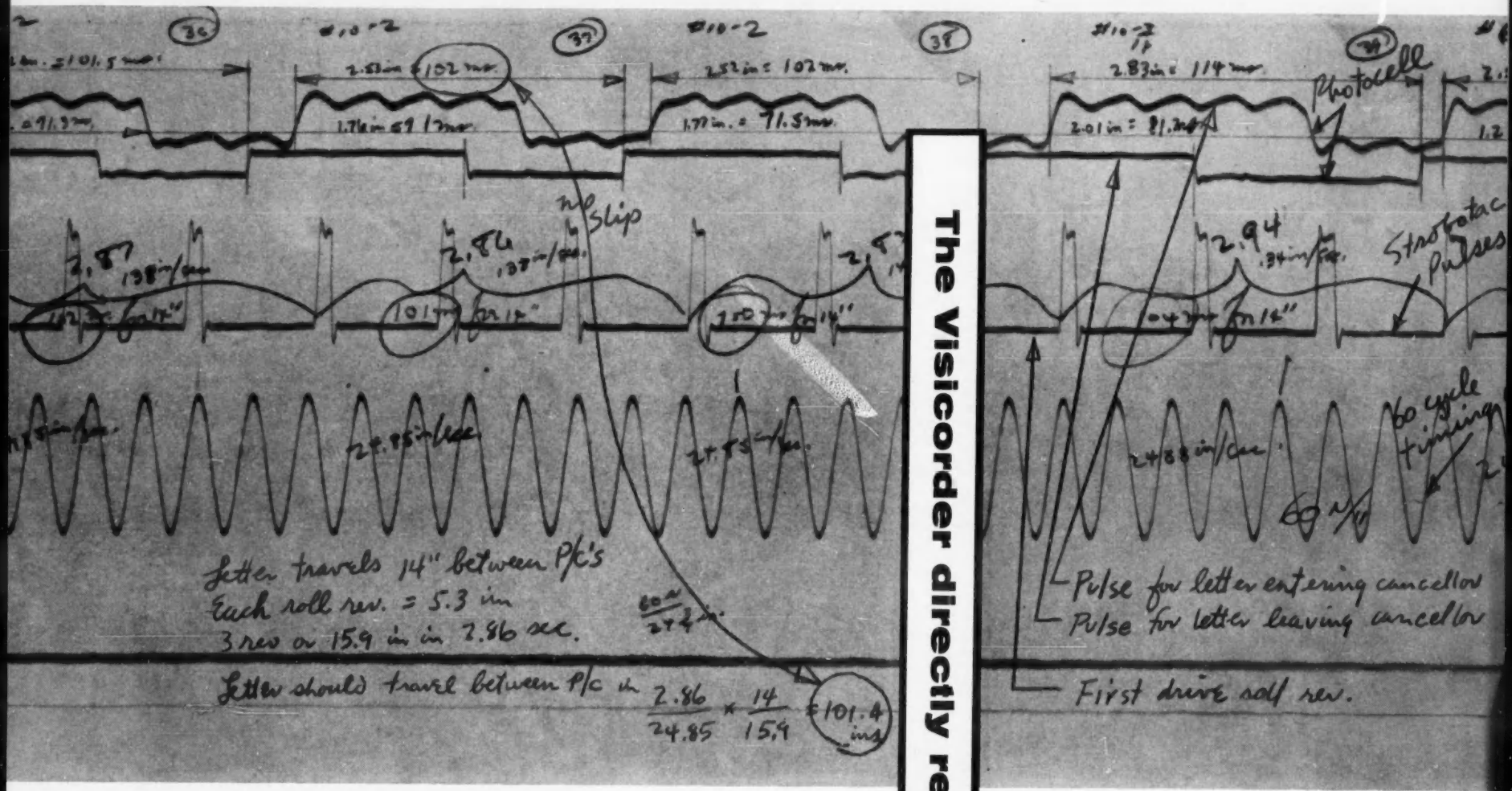
The boom in the dc drives business is traceable mainly to the industrial modernization and automation movements. It has become almost axiomatic that the addition of adjustable speed is an essential element for upgrading the automaticity of machines and processes. So the increased spending for plant improvement planned by various industries for the sixties is sure to push dc sales. The big customers of 1960 will be led by steel and paper manufacturers and will include the rubber, automotive, machine tool, and chemical industries.

Other spurs

But there are other spurs which may not seem so obvious. One most important influence behind the scenes is the fact that much of the dc drive business is special; less than 50 percent of the sales volume will come from off-the-shelf items. And usually when the user calls for a special drive, he almost invariably wants a lot of controls to go with it. Thus, the Big Three have very definitely found themselves in the systems business. Systems, such as a recent $300,000 order for steel mill drives, run up the yearly sales total very quickly.

Another vital aid to the sales of adjustable-speed dc drives is the development of low inertia dc servomotors with astounding response characteristics as a byproduct of the recently completed NEMA rerating program. A 1-hp unit of this type made by Reliance, for example, can be switched from 4,000 rpm forward to 4,000 rpm reverse in about a quarter of a second. Such characteristics have opened up to dc drives uses that were previously restricted to the inherently low inertia, high power, compact hydraulic systems. Within the next year, manufacturers will widen the range of available servomotor horsepower ratings. In contrast to hydraulic drives, the electrical servos offer the advantage of compatibility with the control system which is normally electrical to begin with.





Unretouched Honeywell Visicorder record, actual size.

The Visicorder directly records

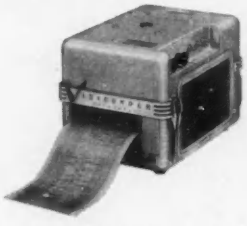
The Emerson Research Laboratories at Washington, D.C., directly-recorded this chart on a Honeywell Model 906 Visicorder. The chart shows a canceller test of a number of letters through a new mail-handling machine developed by Emerson for the U.S. Post Office Department.

In this test, the Visicorder took only 3 hours to reveal information that would have taken 3 weeks to get by any other means: what factors were responsible for the changing speeds of letters as they traveled through the machine at the rate of 30,000 letters per hour. Constant letter-travel speeds were necessary in order to register the cancellation mark on the stamp every time.

This Visicorder record revealed that motor speed variations, belt slippage and slippage of the letter in the drive rollers were responsible. A synchronous drive motor, a timing belt drive and a better grade of rubber in the drive rollers were added to solve the problem—at a vast saving in engineering time.

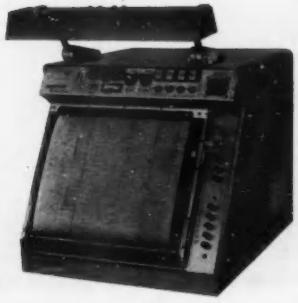
Milton Stovall, Emerson Project Engineer, uses the Visicorder to measure roller bounce caused by various letter thicknesses, and the consistency of letter speed through the new Emerson Automatic Mail Cancelling and Facing Machine.

high-speed letter travel



Recent Models of the 906 Visicorder incorporate time lines and grid lines and record up to 14 simultaneous channels of data.

The NEW Model 1108 Visicorder, with many automatic features and the convenience of pushbutton controls, is ideal for intermediate uses requiring up to 24 channels of data.



The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for recording as many as 36 channels of data.

The Honeywell Visicorder is the pioneer, completely proven, and unquestioned leader in the field of high-frequency, high-sensitivity, direct-recording ultra-violet oscillography. Here are some of the reasons why Visicorders provide the most accurate analog recordings available: constant flat response and sensitivity of galvanometers; grid-lines simultaneously recorded with traces to guarantee exact reference regardless of possible paper shift or shrinkage; flash-tube timing system for greater accuracy of time lines; superior optics for maximum linearity of traces.

No matter what field you are in . . . research, development, computing, rocketry, product design, control, nucleonics . . . the high-frequency (DC to 5000 cps) Visicorder Oscillograph will save you time and money in data acquisition.

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Reference Data: write for Bulletins 1108, 1012, and HC906B

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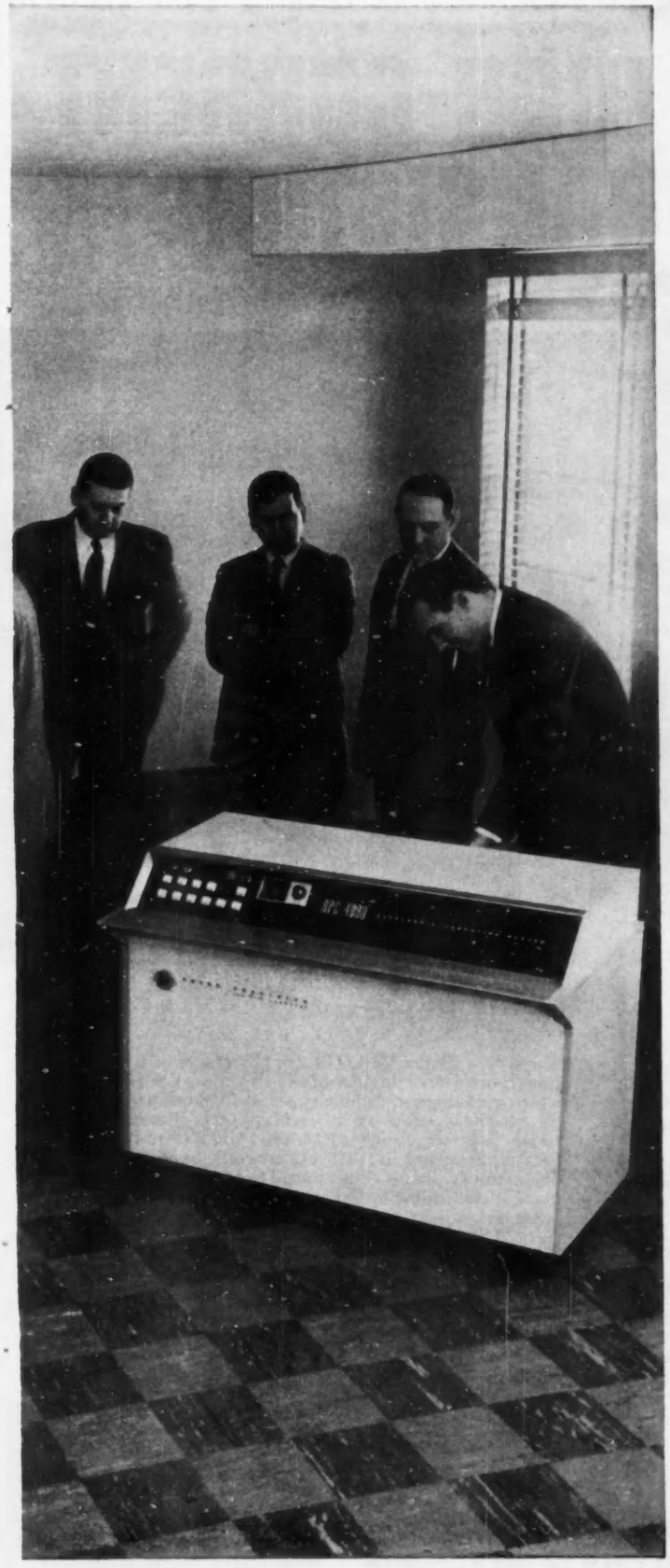
RPC-4000 ELECTRONIC COMPUTING SYSTEM



The RPC-4000 is a new, fully-transistorized electronic computing system with the largest memory, greatest problem-solving capacity and flexibility in the low- or medium-priced field. It is the latest member of a growing family from the people whose LGP-30 has become the world's leading small-scale computer.

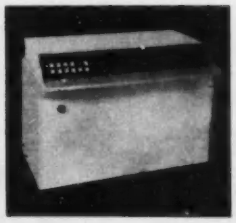
Wide range of applications: the RPC-4000 has been designed for engineering, scientific, business data processing and management control functions. Such jobs as product and process design, statistical analysis, research, inventory control, payroll and sales analysis are all well within its capabilities.

Easy to use: the RPC-4000 is simple to program and operate. Royal McBee compiling and translating routines allow even non-technical personnel to obtain maximum results. Versatile command structure gives programming speed and flexibility.

Available at low cost: high capacity, flexibility and ease of operation make the RPC-4000 the outstanding computer value on the market today.

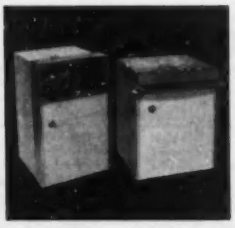
Minimum operating costs: the RPC-4000 requires no site preparation or special maintenance. It is powered from any ordinary wall outlet.

Continuing assistance: users benefit from free training, an information exchange service, and library of programs.



Heart of the RPC-4000 system is a new transistorized computer with advanced design concepts that provide substantial computing speed and capacity in a low-cost unit. Magnetic memory drum stores *8008 words*. Operating speeds are as high as 230,000/minute.

Standard input-output is a tape typewriter system which includes a Royal electric encoding-decoding typewriter complete with desk and chair, plus a tape punch-read console. Read speed is 60 characters/sec., punch speed 30 characters/sec. Typewriter, punch and reader may be interconnected in any combination for both on-line and off-line operations.



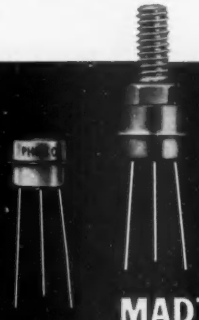
A new 500 character/sec. photoelectric tape reader and a 300 character/sec. punch are available as optional input-output equipment. A magnetic tape unit and a line printer will be available soon. As many as 17 input-output devices (60 with minor modification) may be connected on-line to the basic system. All peripheral equipment is under automatic program control of the computer.

Royal Precision Corporation

Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. RPC-4000 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing Offices. For full, detailed specifications on the new, transistorized RPC-4000, write **ROYAL McBEE** data processing division, Port Chester, N.Y.

PHILCO ANNOUNCES

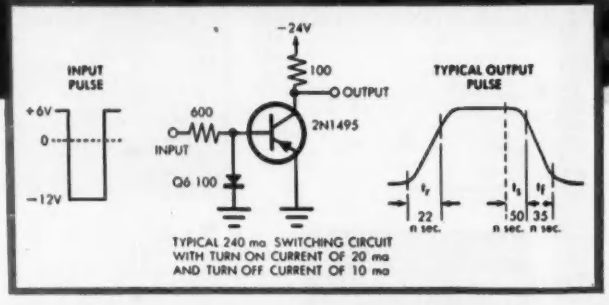
THE FASTEST HIGH-CURRENT SWITCHING TRANSISTORS!



MADT*

2N1495 • 2N1496
2N1204 • 2N1494

These Diffused-base Transistors are capable of utilizing the full speed of new magnetic film memory planes



TYPICAL 240 ma SWITCHING CIRCUIT WITH TURN ON CURRENT OF 20 ma AND TURN OFF CURRENT OF 10 ma

These new Philco MADTs are the result of a revolutionary new development of the Precision-Etch process, which gives high switching speed at high currents. *They are capable of switching 400 milliamperes of current at a 10 mc clock-rate* . . . and are the only transistors available today that permit full utilization of high-speed magnetic film memory planes. The typical f_T of 120 mc at 100 ma makes these units particularly suitable for video drivers, pulse line drivers and other high-current switching circuits. The ultra high-frequency response at the levels normally encountered in current-switching logic circuits, coupled with high dissipation capabilities, makes these units desirable for this class of circuit application.

Both the 2N1495 and 2N1204 are available in studded versions for higher power applications. Typical characteristics are shown in the accompanying table. For complete application data, write Dept. CE-360.

TYPICAL CHARACTERISTICS

TYPE	CASE	P_T @25°amb. (Max)	V_{CES} (Max)	$V_{CE(SAT)}$ $I_C=-200ma$ $I_B=-10ma$	V_{BE}	h_{FE} $V_{CE}=-1v$ $I_C=-200ma$	f_T $V_{CE}=-10v$ $I_E=25ma$
2N1495	TO-9	250mw	−30v	0.35v	0.60v	60	320mc
2N1496	TO-31	*0.5w	−30v	0.35v	0.60v	60	320mc
2N1204	TO-9	250mw	−20v	0.35v	0.60v	60	320mc
2N1494	TO-31	*0.5w	−20v	0.35v	0.60v	60	320mc

*At 25°C case temp.

*Reg. U. S. Pat. Off.

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MARCH 1960

The Great Electronic Haystack

"It's the biggest and the best. There's something in it for everyone interested in electronics, but exactly what's in it for me? Which technical sessions that I should have attended have I missed? When and where were they? Uncovering all of the papers out of which I might get some information helpful in my job is worse than finding a needle in a haystack," groaned an engineer attending the national IRE meeting last year. He had come to town to get up-to-date on the latest developments in electronic control techniques. He found sessions on just about everything in electronics, but their composite coverage was so broad and there were so many concurrent sessions that he was having an awful time organizing his schedule.

The exhibit gave him the same difficulty. Yes, there were roadsigns. In fact aisles were posted with familiar classifications of electronic equipment of major commercial importance. And there was one suburb called "electronic systems". Even so, he had to trudge up and down each alley to find exhibits having to do specifically with instrumentation and control. Small wonder when we consider that the control engineer is interested in equipment combinations that don't fit well-worn pigeonholes. Test instruments, checkout systems, electromechanical rotating components, solid state components, telemetering systems, and logic modules are homogeneous as far as he's concerned but apparently heterogeneous in the eyes of the electronics industry.

We resolved to help our friend. We would not route him through the exhibit; that would be up to the exhibitors. But we would guide him through the sessions of the 1960 national IRE meeting. To accomplish this, we would do two things in the March 1960 issue of CtE. First, we would publish articles that would demonstrate the variety of the latest applications of electronics in the control field. Second, we would slice down through the 60 to 70 technical sessions and select those of greatest interest to control engineers. We'd list them in a special calendar. You'll find the calendar on pages 22 and 23, along with an analysis of what to expect in the sessions.

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Presenting hp 524D Electronic Counter

New 8-decade numerical readout!
New $5/10^8$ per week stability!

SPECIFICATIONS

(Basic 524D without plug-ins)

Frequency:

Range: 10 cps to 10.1 MC

Gate Time: 0.001, 0.01, 0.1, 1, 10 secs or manual

Accuracy: ± 1 count ± 0.000005%

Reads in: KC. Automatic decimal

Period:

Range: 0 cps to 10 KC

Gate Time: 1 or 10 cycles of unknown

Accuracy: ± 0.3% (1 period)
± 0.03% (10 period average)

Stan. Freq. Counted: 10 cps, 1 KC, 100 KC, or 10 MC, or external

Reads in: Secs, msec, μsec

General:

Registration: 8 places (99,999,999 max.)

Stability: 5/100,000,000. May be standardized with WWV or external 100 KC or 1 MC primary standard.

Display Time: Variable 0.1 to 10 secs; or "Hold"

Input Voltage: 1 v min, 1.5 v peak. Rise time 0.2 seconds max.

Input Impedance: Approx. 1 megohm; 40 μμf shunt.

Price: $2,150.00 f.o.b. factory.

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plus all these frequency and time measuring advantages!

Direct, instantaneous, automatic readings

Frequency coverage 10 cps to 220 MC*

Time interval 1 μsec to 100 days

Resolution 0.1 μsec

High sensitivity, high impedance

No calculation or interpolation

New convenience of uniform 8-decade numerical readout without meters — new 5 parts in 10^8 stability simplifying standards and other microwave measurements — this is the capsule story of the new *-hp-* 524D Electronic Counter.

Electrically similar to the widely used *-hp-* 524B Counter, the new 524D provides for full frequency measurements from 10 cps to 10 MC and period measurements from 0 cps to 10 KC. Low cost plug-in units extend frequency measuring range to 220 MC, permit period measurements of over 10,000 periods, and increase sensitivity for precise measurement of weak signals. Still another plug-in provides for time measurements from 1 μsec to 100 days with 0.1 μsec resolution. When used with *-hp-* 540A Transfer Oscillator, the 524D will measure accurately to 12 KMC. For complete details, write or call your *-hp-* representative; or write direct.

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Techniques and Equipment for Digital Data Conversion

THE GIST: Digital systems store recorded data in many forms, such as punched cards, paper tape, and magnetic tape. One kind of record is usually better than another in any particular application, so the characteristics of digital recordings often differ in equipment that must work together. For example a data collection subsystem that produces occasional punched cards may be part of a large data processing system designed to operate efficiently by reading its input data from magentic tape at very high speeds. In such cases equipment is needed to transcribe digital data from one recording medium to another. Such "conversions" usually require code translation and often include some amount of editing. This article discusses the techniques which have been developed for converting digital data and describes a number of typical commercial conversion equipments.

ROBERT F. SHAW, Digitronics Corp.

Data conversion can take many different forms, of varying complexity. There is room for argument over the question of where "conversion" becomes "computing" or "data processing". (Obviously, in one sense of the term, all conversion can be called data processing.) Common practice in the field, however, is to confine the term "conversion" to transcription of data from one medium to another. In addition to the basic provisions for reading data from one medium and recording them in another, there are several other elements which may be present in a conversion system. These can be classified into four principal categories:

• **Code translation**—for a variety of reasons, partly historical and partly having to do with equipment logic, any two recording media generally use different codes for representing digital data. Thus, conversion devices will almost always include a code translator. If the codes at input and output bear some logical relation to each other, the translator may be fairly simple, as is the case in several card to tape converters where the tape code was purposely chosen to bear a simple relation to the card code. In many cases, specifically those involving teleprinter code, no relationships exist to simplify the translation process, and a full translator involving complete decoding and encoding must be used.

• **Buffering**—this term applies here to the matching of different information rates at input and output, or to conversion from serial to parallel data representation or vice versa. Some buffering is usually unavoidable. To take two common examples: punched cards are most easily and reliably read in parallel (row by row), while both paper and magnetic tape use serial representation of data; magnetic tape cannot easily be read at very low speeds, while mechanical difficulties limit the maximum speed of punching paper tape. Buffering requires an internal memory in the converter which makes it simple to read in at one rate and out at a different rate or to read in in parallel and out serially.

• **Editing**—it is often necessary to have the converter perform more than just a character-for-character transcription of data from one medium to another. The reasons for this are discussed in some detail later, and will not be taken up here, except to mention that the memory required for buffering is often useful for the editing process.

• **Checking**—reduction of errors, and in particular reduction of undetected errors, is of primary importance in any data processing system. Thus in addition to making every reasonable effort to design conversion equipment for reliable operation, it is usually necessary to include certain self-checking features. In many cases the input medium will carry data recorded in a self-checking code; this is almost always true of magnetic tape and is sometimes true in the case of punched tape and other media. In such cases input data are checked as they are read, and provision is sometimes made for automatic rereading of a block of input data if an error is detected. If the converter uses an internal memory, an additional check can be made by storing redundant data and checking as the data are read out to the recording circuits.

Direct translation

Aside from the unusual case of transcription alone, direct translation is the simplest type of conversion. In this operation each character of the input data produces one and only one character of output data, although input and outputs are in different codes. Aside from

Message	Input Tape (Univac code)	Output Tape (IBM 705 code)
C	0 01 0110	0 11 0011
O	0 10 1001	1 10 0110
N	1 10 1000	1 10 0101
T	1 11 0110	1 01 0011
R	0 10 1100	1 10 1001
O	0 10 1001	1 10 0110
L	0 10 0110	1 10 0011
Space	0 00 0001	
E	1 01 1000	0 11 0101
N	1 10 1000	1 10 0101
G	0 01 1010	1 00 0111
I	0 01 1100	0 11 1001
N	1 10 1000	1 10 0101
E	1 01 1000	0 11 0101
E	1 01 1000	0 11 0101
R	0 10 1100	1 10 1001
I	0 01 1100	0 11 1001
N	1 10 1000	1 10 0101
G	0 01 1010	1 00 0111
,	1 01 0001	0 01 1011
Space	0 00 0001	
1	0 00 0100	1 00 0001
9	1 00 1100	0 00 1001
6	1 00 1001	0 00 0110
0	1 00 0011	0 00 1010

FIG. 1. Direct translation causes character by character transcription of data to new code.

Message	Input (IBM 705 code)	Output Teleprinter code	Notes
	none	11011	1
5	0 00 0101	00001	
7	1 00 0111	11100	
	none	11111	2
A	1 11 0001	11000	
F	0 11 0110	10110	
	none	11011	1
2	1 00 0010	11001	
Space		00100	
	none	11011	1
@	0 00 1100		
Space		00100	
	none	11011	1
3	0 00 0011	10000	
5	0 00 0101	00001	
	none	11111	2
C	0 11 0011	01110	
Space		00100	
E	0 11 0101	10000	
A	1 11 0001	11000	
G	0 11 0011	01110	
H	1 11 1000	00101	

Note 1 – Shift to uppercase Note 2 – Shift to lowercase

FIG. 2. Selective translation with additions is necessary when translating to or from teleprinted code, which requires case shift to remove ambiguity.

the code translation, input and output formats differ only in the possible presence or location of inter-record gaps (where input, output, or both use tape). Figure 1 shows, in the "one-zero" representation commonly used in computer literature, how the words CONTROL ENGINEERING, 1960 would appear on the input and output tapes of a converter designed to convert Univac tape to IBM 705 tape. The "one-zero" codes have been spaced out to indicate the parity, zone, and sector groups in that sequence; note that in the two codes shown the zone and sector groups can be independently translated insofar as alphanumeric characters are concerned (although this is not true for special symbols). The significant characteristic in the example of Figure 1 is that there is a one-to-one correspondence between input and output characters.

Deletions, additions, selective translation

To relieve a data processor of as much routine work as possible, it is customary to perform as much "editing" as possible in the conversion equipment. Thus the direct translation just described seldom fulfills all the requirements for a data converter. Of the many possible editing operations, probably the simplest is the deletion of certain parts of the input data or the addition of extra characters. This is often accompanied by selective translation—that is, translation of one character into either of two or more characters, depending on such things as position in the record or the occurrence of specified characters preceding those to be selectively translated.

A common example of addition or deletion accompanied by selective translation occurs in converting between five-level teleprinter code and any of the six- or seven-level alphanumeric codes commonly used in data processing. Figure 2 shows how "57AF2 @ 35c each" would be converted from IBM 705 code to teleprinter code. Every time there is a change from letters to figures or vice versa, the converter must insert an appropriate case shift character on the output tape. The space character causes the teleprinter to shift to lower case, and thus a shift back to upper case must be made when a figure follows a space, although the space itself can be made regardless of the state of the machine when it occurs. Note that translation is selective in a sense, in that both E and 3 translate into the same code after any necessary case shift has been made. If conversion in the opposite direction (teleprinter to IBM 705) was involved, teleprinter code 10000 would translate into either of two 705 codes, depending on the identity of the last case shift character preceding the 10000 code.

Another type of selective translation depends on the position of a character in the record. If the characters in each record are numbered from 1 through 80, for example, and the converter is provided with a plugboard having a hub for each of the 80 characters, a signal corresponding to any specified character in the record can be obtained by pulsing these hubs sequentially as data flow through the converter. Then it becomes a relatively simple matter to use the signals from these character position hubs to control the translation process; by plugging a wire from hub 63, for example, into a translation control circuit also wired to the plugboard, character 63 in each record can be made to translate differently from other characters. The most familiar

application of this type of selective translation occurs where punched cards form the input—in certain columns an X punch may simply mean that the character in that column is one of the letters J through R depending on which other row is punched. In other columns the X punch may have a different significance, such as indicating a credit balance, and any other holes in those columns are to be interpreted as representing numbers. The translation control used in this situation is punched card equipment is that of the familiar "column split".

Signals from the character position hubs can also be connected through plugboard wiring into circuits which will insert spaces or other symbols in the output data preceding or following the corresponding input character. Likewise, by means of suitable plugboard connections, it becomes possible to delete unwanted characters or fields.

Rearrangement

In some cases it is desirable to rearrange, during the conversion process, the sequence in which data fields appear. This is most frequently necessary in preparing copy for a printer, where data from a single file are to be used in the preparation of two or more different printed reports having varying formats. Where both input and output are serial, rearrangement is not possible unless an internal memory is used. If either input or output is parallel—i.e., if all characters in an item appear on separate wires rather than in time sequence on a single wire—rearrangement becomes a very simple plugboard operation. Thus rearrangement is easy if the input is from punched cards (unless the cards are read endwise, column by column) or if the output is to punched cards or to a line printer.

TYPICAL CONVERSION EQUIPMENT

Certain conversion equipment currently in use will be described to illustrate some typical digital data converters and indicate the wide variety of equipment now available. Enough descriptive material has been included to give the reader with some knowledge of digital techniques an idea of how various conversion problems have been attacked.

Card to card

Reproducing punches, which are actually card to card converters, have been in use for many years and are familiar to anyone acquainted with punched card equipment. Figure 3 indicates the basic connections between input and output, omitting details such as start, stop, and interlock controls and some plugboard features.

In the illustration the plugboard has been set up to punch data from columns 7-12 inclusive of each input card into columns 25-30 inclusive of a corresponding output card. If no other plugboard connections are used, data in columns 1-6 and 13-80 of the input cards will not appear in the output cards. The process shown is a rearranging operation. In actual practice the plugboard will have facilities for setting up column splits, punching certain predetermined characters into output cards which do not appear in the input cards, and other more complex operations.

The reading or punching facilities of these devices have led to their occasional use in conjunction with other types of conversion equipment, where punched cards form either the input or the output.

Card to paper tape and paper tape to card

Among the first of the digital data converters to be made generally available were the IBM 63 Card Controlled Tape Punch and IBM 46 Tape-to-Card Punch. These units were originally designed for transmitting punched card data over teleprinter circuits which had used punched tape input for many years. More recently converters have become available for direct connection of card readers and punches to communication circuits without use of punched tape, as described in a later section of this article. But the convenience of punched tape, particularly when tie-ins to page printers are necessary, has resulted in continued widespread use of the 63 and 46 converters. The increased use of various data originating devices, such as point-of-sale recorders which generate punched tape, has provided additional demand for paper tape to punched card converters.

The IBM 63 Card Controlled Tape Punch (Figure 4) uses a serial (column-by-column) card reader, resulting in appreciably simpler equipment than would be possible with a conventional parallel (row-by-row) reader. This is a natural choice, since the output data must be in serial form for punching the tape, and the greater reading speed of parallel card readers would be wasted in view of the limited rates at which simple mechanical tape punches can operate.

Editing facilities are provided through a plugboard. Such operations as skipping certain columns, column splits, punching extra characters like carriage returns, and selective translation are provided through the plugboard. Output tape is five-channel, and case shifts are automatically inserted wherever required. Both input and output are serial, and no internal memory is used; thus as already noted, it is not possible to rearrange data. In the few cases where rearrangement is necessary, the card to paper tape conversion can be preceded by a card to card conversion on a reproducing punch.

The IBM 46 Tape-to-Card Punch and the type 47,

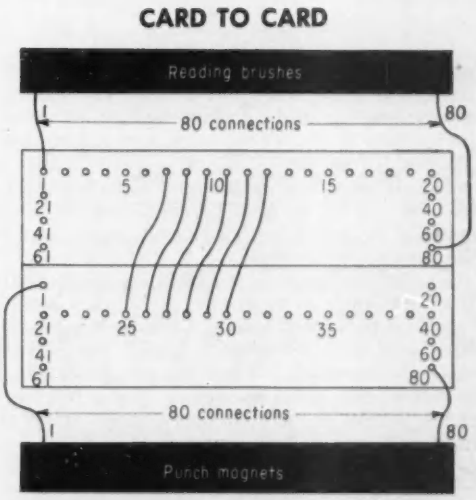


FIG. 3. Reproducing punch, or card to card converter, showing connections for data rearrangement.

CARD TO PAPER TAPE

FIG. 4. IBM Model 63 Card-Controlled Tape Punch.
(Photo courtesy International Business Machines Corp.)

CARD TO MAGNETIC TAPE

FIG. 5. Univac Card to Tape Converter.
(Photo courtesy Remington Rand Univac Div., Sperry Rand Corp.)

an interpreting version of the same device, perform conversion from either five-channel or eight-channel punched tape to cards. Editing facilities are quite similar to those of the 63 converter, also making use of a plugboard. Like the 63, the 46 converter is fully serial; in fact the punching mechanism and its associated card feed and controls are quite similar to those of the standard IBM key punch, with a punched tape reader taking the place of the keyboard.

Similar equipment is available for conversion from 90-column cards to paper tape (Remington Rand Type 318 Card to Tape Converter) and from paper tape to 90-column cards (Remington Rand Type 308-5 Tape to Card Converter). These are also essentially serial in nature; even though punching in the 308-5 is completely parallel, the setup of data is serial. Thus editing features do not include rearranging.

Card to magnetic tape

The design of the Univac system, some 13 years ago, included development of the first high speed data converter. This device fed cards at an effective rate of 354 per min, and having no internal memory, effected a simple one-to-one translation without editing. It did, however, provide wide tolerances for reading off-punched cards and had checking circuits for recording on the tape an indication of the occurrence of certain types of mispunching.

The development of a 240 card per min sidewise feed reader and the need for more extensive editing facilities led to the development of the current Univac card to tape converter shown in Figure 5. The card reader is shown at left being loaded by the operator. A standard Uniservo tape transport, shown at the right, is used for the actual tape recording operation. Full editing facilities are provided through the plugboard, permitting the 80 or 90 characters read from a card to be assigned in any desired fashion to the 120 character positions in a blockette on tape. Extensive checking is used.

In the IBM 704 and 705 systems, card to magnetic tape conversion is accomplished not by a separate card to tape converter *per se* but by a combination of equipment modules which can also be used for other purposes. Specifically, a conversion assembly consists of a 714 Card Reader, a 759 Card Reader Control Unit, and a 727 Magnetic Tape Unit. The 714 and 759 can also be used for feeding data from cards directly into the computer, while the 727 is the standard tape unit used throughout the system.

The card-to-tape converter used with the Datamatic 1000 system has a number of interesting characteristics. This device, designated the Model 1200 Card Input System, like those already described, uses a separate card reader (Figure 6), conversion unit (Figure 7), and tape transport. However, the reader operates at very high speed (900 cards per min). Two plugboards are used. A Card Reading Control Panel is used to perform the rearranging function; it permits the 80 card columns to be assigned in any arbitrary sequence to 100 storage locations (the extra 20 locations permitting some fields to be duplicated if desired).

The plugboard has two identical areas, which are to be wired identically, duplicating the entire wiring array; the two areas correspond to two reading stations. In operation the first reading station feeds into a circuit which counts holes in the card by rows, while the second reading station feeds the main card storage. As data are read out of the latter, which stores an image of the hole pattern, a count is made by columns and compared with the count previously made by rows, providing an effective check of card reading accuracy.

The second plugboard (Figure 8) is noteworthy for its simplicity, particularly in view of the wide variety of editing functions possible. All these functions (which, of course, do not include rearrangement, as this was already accomplished through the reader plugboard) have been summarized in 17 "Rules". For example, Rule 1 is "Alphanumeric (Blank Illegal)". Wiring from a "Rule 1" hob to any "Step" hub causes straight alphanumeric translation of the corresponding character from card storage (characters from storage being scanned in the same sequence as steps), with a special indication recorded on the tape if a blank column occurs. Rule 16 is "Filler (Six-Bit)"; wiring from a "Rule 16" hub to any "Step" hub causes no character to be taken from storage in that step, but six "zero" bits are recorded

on tape. (The provision of various "filler" rules accounts for the fact that the plugboard is provided with 180 "Step" hubs, although there are only 100 characters in the card storage.) Other rules cover numerous additional functions, such as column splits or transcription of a column as a 12-bit array of zeros and ones representing the hole pattern in that column.

Magnetic tape to card

Conversion from magnetic tape to cards is not so frequently required as card to magnetic tape conversion, and the variety of equipment available for the purpose is consequently somewhat limited. The reasons for this difference in requirements may be traced to the fact that in a system employing both cards and magnetic tape, the cards are usually used as source media for data entering the system, whereas output data from the computer are more likely to take the form of visible copy produced on a high speed printer. Occasionally, however, card output may be required—usually in situations where card files are required for one reason or another, such as occasional random access reference.

The Remington Rand Univac Magnetic Tape to Card Converter uses a standard Uniservo as a tape reader. An electronic control unit provides storage for 120 characters (one tape blockette) and a plugboard for assigning characters from the blockette to any desired column on an 80-column card. A separate card punch completes the assembly. Checking features include the usual Univac tape parity check and a check obtained by reading data punched in the card and comparing it with the data from the memory which produced the punching. A check is also made for occurrence of tape characters wired to the punch which do not have card code equivalents.

Like the card to tape converter, the tape to card converter of the IBM 705 system is assembled from components all of which can also be used elsewhere in the system. The tape unit is again the 727, which converts to a 722 Card Punch through the 758 Card Punch Control Unit. No editing facilities are provided; tape data must be properly sequenced to permit direct transcription to the card.

Paper tape to magnetic tape circuits

Equipment for conversion from paper tape to magnetic tape or vice versa is required for much the same reasons as paper tape to card and card to paper tape converters—namely, to provide a link to systems employing teleprinter equipment and to transcribe paper tape generated by point-of-sale recorders and other data

CARD TO MAGNETIC TAPE

FIG. 6. High Speed Card Reader of the Datamatic Card to Tape Converter (Photo courtesy Datamatic Division, Minneapolis-Honeywell Regulator Co.)

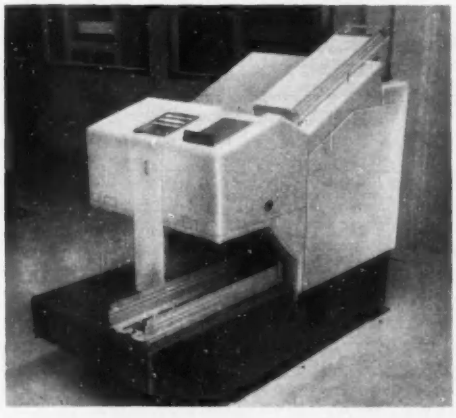


FIG. 7. Conversion Unit of the Datamatic Card to Tape Converter. (Photo courtesy Datamatic Division, Minneapolis-Honeywell Regulator Co.)

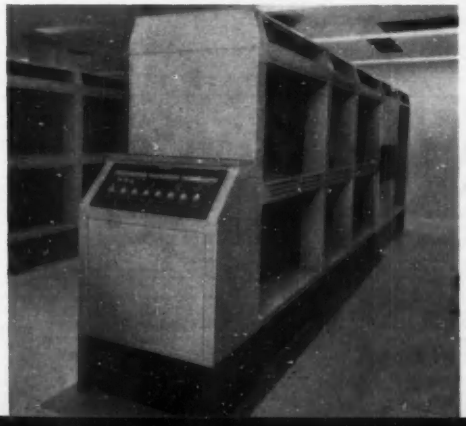
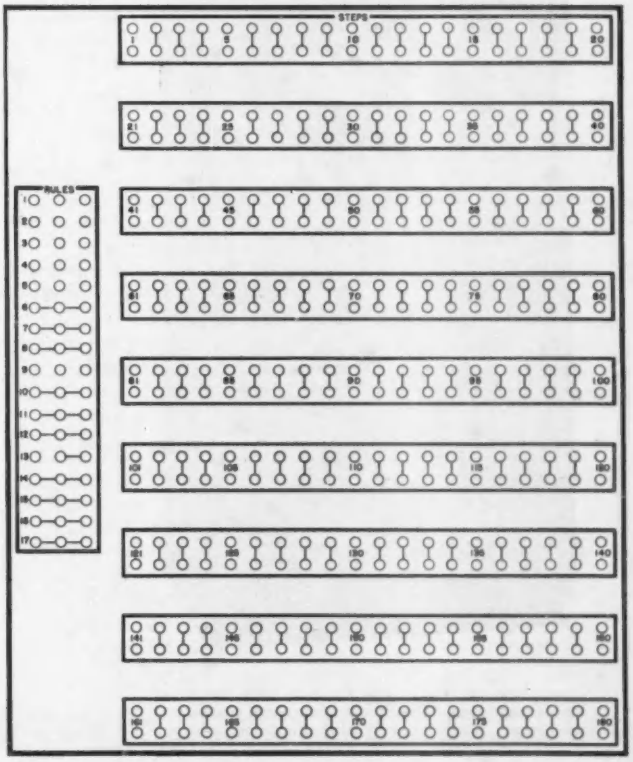


FIG. 8. Conversion Control Panel, Datamatic Model 1200 Converter. (Diagram courtesy Datamatic Division, Minneapolis-Honeywell Regulator Co.)



gathering equipment. Until recently, however, such conversion equipment has not been generally available, but now some manufacturers are producing it.

One of these, the Dykor D104 Converter (Figure 9) manufactured by Digitronics Corp., can convert in either direction between magnetic and punched paper tape. Modular construction permits use of only certain plug-in packages at a corresponding decrease in cost, if the user requires only unidirectional conversion. An internal memory is used, primarily to provide buffering to accommodate the widely different input and output rates and partly to facilitate editing.

Editing is done through a special plugboard (Figure 10). A unique feature is the bringing out of all decoder outputs and encoder inputs to plugboard hubs, permitting complete translation control from any input code to any output code. Checking features include a parity check on magnetic tape input, with an automatic reread of the input block if a parity error occurs. Data from the memory to the output are also given a parity check.

In converting from magnetic to paper tape, selective translation through Translation Controls, Translation Gates, and Column Splits (in central area of plugboard) is possible, and spaces, carriage returns, or line feeds can be added where required (lower part of plugboard). Case shifts are automatically supplied where required by the paper tape code.

Converters for communications circuits

With higher rates of data transmission over communication lines has come a need for conversion equipment to couple such circuits to reading and recording equipment. Equipment for connecting punched tape readers and punches to telegraph circuits has been in use for many years and is familiar to anyone concerned with data transmission, so it need not be discussed here; but converters have now come into general use for transmitting punched card and magnetic tape data over telegraph, telephone, and radio circuits.

The IBM Data Transceiver will either transmit or receive punched card data over communication circuits. Rates vary from 3 to 5 cards per min over telegraph circuits, to as many as 11 cards per min over telephone circuits. In the latter case up to four transceivers can be multiplexed over one circuit.

Editing facilities are confined to skipping of predetermined card columns and automatic control of interpreting, if used. The checking system used is of particular interest. Whereas in magnetic recording systems the error rates are very small and errors are almost exclusively due to dropping of occasional bits, the errors

PAPER TAPE TO MAGNETIC TAPE

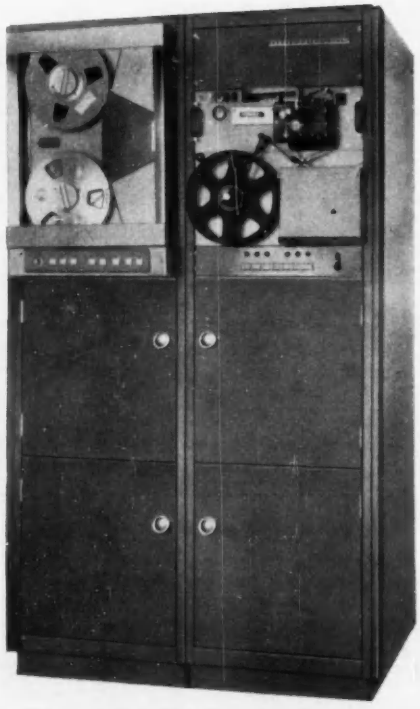


FIG. 9. The Dykor D104 converter, magnetic tape to paper tape model. Opening the door below the high speed punch (right-hand rack) gives access to the plugboard. (Photo courtesy Digitronics Corp.)

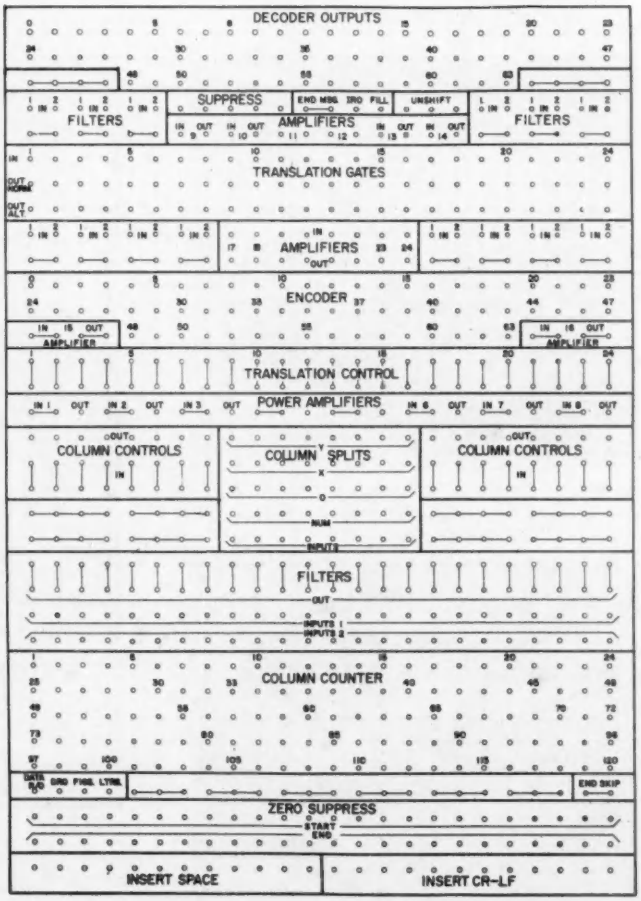


FIG. 10. Plugboard of the Dykor D104 Converter. (Diagram courtesy Digitronics Corp.)

FIG. 11. Collins Kineplex Card Terminal, showing Kinecard Converter, Kineplex Terminal, and summary punch used for either reading or punching cards. (Photo courtesy Collins Radio Co.)

FIG. 12. Collins Kinetape Converter. (Photo courtesy Collins Radio Co.)

on communications circuits are much more frequent, and spurious pickups of bits are about as frequent as dropouts. The transceiver therefore uses a code having higher redundancy than the usual one bit per character used in data processing systems. Each character is represented by an eight-bit group in which there are always precisely four "ones" and four "zeros". Double pickups or double dropouts show as errors, whereas they would not be caught by a simple parity check.

To obtain more complete utilization of voice communication channels for data transmission, Collins Radio Co. some time ago developed the Kineplex system, which through use of a phase-division signaling method effectively, doubles the rate at which digital data can be transmitted over such channels. The first application of the Kineplex equipment was in the multiplexing of 40 teleprinter signals on one voice channel, but conversion equipment for transmission of both punched card and magnetic tape data is now provided.

In the punched card (Kinecard) converter (Figure 11), an IBM 523 card punch, used as either a punch or card reader, is coupled through the card converter shown at left to the regular TE206 Kineplex data terminal shown in the center of the photograph. The 523 operates at its normal rate of approximately 100 cards per min. The assembly of equipment shown is for half duplex operation (alternate transmission and reception), but the same card converter and Kineplex terminal have sufficient capacity to permit full duplex operation over one channel (simultaneous transmission and reception) if a second 523 card punch is added. In this case one 523 would always function as a reader and the other as a punch.

Data from the card are transmitted serially over eight parallel Kineplex channels, each card column being encoded into an eight-bit character. Two additional eight-bit characters are appended to the data from each card and carry parity check data. A core matrix memory is used to assemble card data from the reader or to distribute the data to the IBM summary card punch.

By substituting a Kinetape converter (Figure 12) for the Kinecard converter and 523 punch, magnetic tape data from either IBM or Univac tape may be handled through the same TE 206 Kineplex terminals. The system operates in the half-duplex mode, transmitting 300 alphanumeric characters per second. Extensive parity checking is used, and an outstanding feature of the system is automatic retransmission of a block of data found to contain an error.

Converters for garment tags

Some years ago the manufacturers of price tags used in the garment industry introduced tags which can carry information as to style, price, etc. in the form of hole patterns corresponding to printed figures on the tags. At the time a garment is sold, a portion of the attached tag is torn off and eventually fed through a converter which reads the hole pattern and transcribes the data to other recording media suitable for use in a data processing system. Thus sales analysis and inventory control are considerably simplified.

Until recently the garment tag readers in use were designed to transfer data to punched cards. They were relatively expensive, and thus the practice has been to collect the tags at central locations serving several stores of a chain. Recently, however, equipment has been developed for point-of-sale conversion of tag data to paper tape. Two such converters have recently been offered to the retail trade. National Cash Register Co. has a converter which transfers data from garment tags to punched paper tape, and Minnesota Mining and Manufacturing Co. offers a reader which transfers an exact-size image of the hole pattern in the tag to a heat-sensitive paper tape.

Universal converters

Although universal converters, which accept input from any of several media and record on any of several

UNIVERSAL CONVERTERS

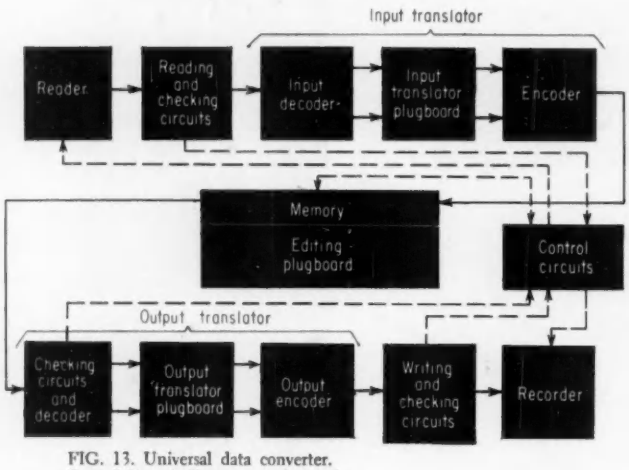


FIG. 13. Universal data converter. Dotted lines indicate control signals, and solid lines indicate data signals.

FIG. 14. NCR Model 320 Universal Converter. (Photo courtesy National Cash Register Co.)

output media, have often been discussed over the past several years, it is only recently that such equipment has actually become available. Figure 13 shows a simplified block diagram of a universal converter.

The reader and recorder are selected according to current requirements and changed as required; other components remain the same for any combination of input and output. A particular combination of input and output may not (in fact will not, in general) require all facilities. For example, certain recording media may not provide for checking data read or recorded, and one of the translators may be omitted if the internal code used by the converter coincides with that used on input or output. In practice a converter would be designed to handle six parallel channels of data at input, output, and internal memory; these in many instances will be accompanied by parity, sprocket, field definition, or other channels in parallel with the six data channels. Thus each translator will consist of a 6-to-64 decoder, a plugboard with 64 entry and 64 exit hubs, and a 64-to-6 encoder; parity bits may be handled at encoder or decoder or both, resulting in a 7-to-64 decoder or a 64-to-7 encoder. Theoretically only one translator is required, as the internal code can always be made to correspond to either input or output code, but there are a number of practical advantages to using a constant internal code regardless of input and output, and these may in many cases offset the cost of the extra translator.

If punched cards are handled in the usual manner—i.e., row by row—at either input or output, the reading or writing circuits will be correspondingly increased in complexity as a result of the parallel operation; and in certain situations an additional input or output storage register may be added to facilitate the operation.

Control circuits govern the starting and stopping of input and output devices and the flow of data through the converter. Since detection of an error will in most cases be an occasion for stopping the process and in others will be used to back up an input tape and reread the input block, all check circuits are connected to the control circuits.

An example of a universal converter is the Dataverter, designed jointly by Digitronics Corp. and Epsco, Inc., and produced by Epsco. The Dataverter has all elements shown in Figure 13 including both translators. The internal memory is of the shift register type but with facilities for either sequential read-out or random read-out under plugboard control. Thus the editing plugboard can be used for rearrangement as well as the usual character deletions and additions. In the pilot model of the Dataverter, the input and output facilities provide for handling IBM 704 or Univac 1103A magnetic tape, punched paper tape (five-, six-, seven-, or eight-level), punched cards (one or two cards per record), or typewriter. The internal memory has a capacity of 120 characters, which is consequently the maximum record length, although provision is made for using the code translators but bypassing the internal memory when transcribing longer records from one magnetic tape to another. An additional feature of the Dataverter is an automatic search, which on certain types of operation permits a specified number of input blocks to be passed over before normal operation begins, after which a specified number of blocks are acted upon.

The National Cash Register Co. also produces a universal converter for use with their National 304 Electronic Data Processing System. This device (Figure 14), known as the Model 320 Universal Converter, can accept data from either cards or punched tape for recording on magnetic tape or from magnetic tape for recording on punched cards, punched tape, or a line printer. Both the card reader and paper tape reader used with the system are quite fast, operating at 1,500 cards per min and 1,800 characters per sec respectively.

The Model 320 Converter has several checking features including parity checks on magnetic tape input (and on paper tape input if a self-checking code is used), dual reading and other checks on cards, and internal parity and sum checks. A search feature is included as is a manually controlled reread for magnetic tape input blocks. Editing is by plugboards in the input and output devices for punched cards or line printer.

Installing Rotameters

Rotameters fulfill a variety of flow measuring services in many different industries. Their satisfactory performance depends on on good installation practices; the following information, based on agreement of instrument engineers from many petroleum companies, serves as a guide for installing them.

AMERICAN PETROLEUM INSTITUTE
Committee on Refinery Equipment
Subcommittee on Instruments*

Rotameters are valuable for measuring flow rate under unusual and special service conditions. Perhaps their greatest service is for metering small flows as in purging and blending. Rotameters have a wide maximum-to-minimum range of flow rates (almost 10 to 1) and meet the needs of frequent on-off service. Furthermore, they can be applied to slurries, streams exhibiting such characteristics as high volatility and high viscosity, and streams subject to congealing or freezing (chemicals, waxes, and asphalts).

Rotameters offer signals with good linearity as needed for proportioning two or more flows or for simple correlation of a flow signal with other linear signal variables. They are available as indicators, transmitters, recorders, and controllers—in any combination. However, rotameters are relatively expensive in the large sizes. Glass-tube meters should not be specified for general hydrocarbon or other hazardous service.

The rotameter should be installed in a vibration-free location with sufficient clearance available for occasional float removal for inspection or range changes. It should be located so that its scale graduations are visible and it is readily accessible for operation and maintenance. In general, when used in regulating service, the rotameter should be located as close as possible to the throttling point—preferably with the regulating valve at the outlet fitting.

Mounting—Rotameters should always be mounted vertically with the outlet (downstream) connections at the top of the meter and the inlet (upstream) connections at the bottom; that is, the highest scale graduations and the largest part of the metering tube are at the top. A plumb bob or equivalent device should be used to check vertical alignment. Both accuracy and sensitivity will be affected if the rotameter is not mounted in a vertical position. A vertical misalignment of 12 deg, for instance, will affect the accuracy about 1 percent. Rotameters may be mounted on either side of a panel or installed directly in either a horizontal or a vertical pipeline. When using panel mounting, the panels should be rigid, vertical, and free from severe vibrations.

Piping—Most variable-area flow measurement installations will be practically independent of upstream piping arrangements. Elbows, globe or throttling valves, and other fittings have no effect on measurement accuracy if they are no closer than five pipe diameters upstream. Where connections are interchangeable (for vertical or horizontal inlet

*This article is based on a portion of Section 1, Flow, of the API's forthcoming "Manual of Recommended Practices for Installing Instruments in Refineries". Publication is planned for early 1960. Copies will be available from the American Petroleum Institute Order Dept., 111 West 50th St., New York 20, N. Y.

WHAT IS A VARIABLE-AREA FLOWMETER?

Area meters fall into two classes: the rotameter and the piston type. In contrast to the common orifice meter, which has a fixed-area opening but a changing differential pressure with varying flow rate, the area meter has a relatively constant pressure drop across a variable-area orifice. The usual rotameter has a weighted plummet inside a tapered tube. The annular clearance between the plummet and the varying diameter inside the tube constitutes the variable-area orifice. The plummet reaches an equilibrium position proportional to flow rate when the upward force of the fluid passing through the annular orifice equals the downward force of the plummet.

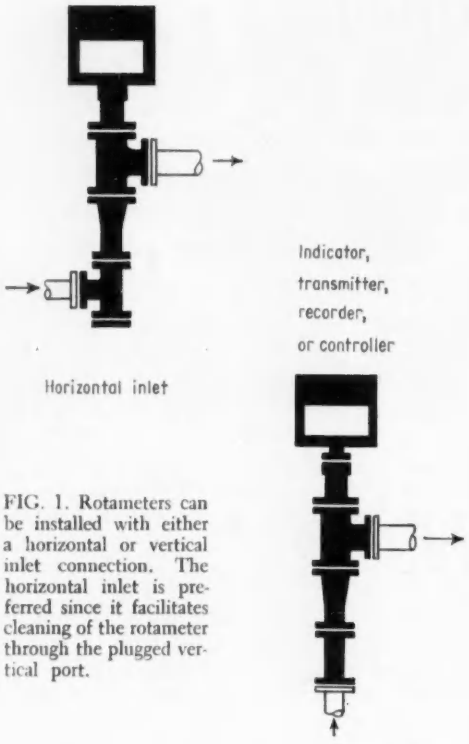
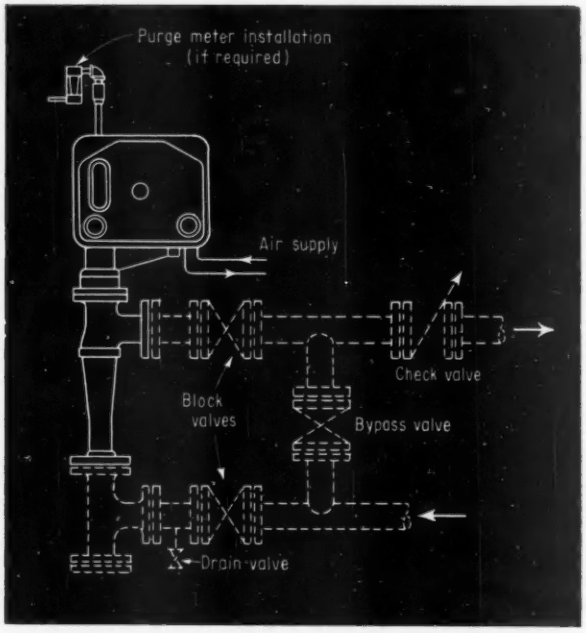


FIG. 1. Rotameters can be installed with either a horizontal or vertical inlet connection. The horizontal inlet is preferred since it facilitates cleaning of the rotameter through the plugged vertical port.

FIG. 2. Block and bypass valves permit process operation whenever the rotameter must be opened for maintenance. The check valve protects against flow reversal.



connections), it is recommended that the horizontal connection be used if at all practical in the overall piping arrangement. Horizontal connection permits using the plugged vertical opening as a convenient cleanout port. The design of most rotameters permits the end fitting to be rotated in 90-deg increments, allowing a convenient variety of connection arrangements. Figure 1 shows typical rotameter piping connections.

All piping must be sufficiently braced and reinforced to prevent sagging due to the meter's own weight. Care must be taken to assure that the piping arrangement does not impose any strain on the meter body. Sometimes it is advisable to install a brace between inlet and outlet piping.

Bypass piping—A check valve should be installed after the downstream block valve in gas measuring services and in those services where backflow or liquid hammer may exist. Block and bypass valves, Figure 2, may be provided to permit process operation while the meter is being serviced. Some service conditions often requiring opening of the meter for servicing are dirty fluids, slurries, corrosive or erosive media, fluids with high solidification point, or even pipe scale in the case of small meters.

The bypass line and valves should be main line size. Block valves should be installed upstream and downstream of the rotameter, with a drain valve inserted between the inlet block valve and the rotameter. Only the downstream block valve may be used for throttling when flashing might be encountered.

Strainers—In smaller rotameter sizes it is sometimes advisable to locate a strainer upstream of the meter to prevent jamming the float with pipe scale or other foreign material. A strainer should not be used, of course, in slurry services.

Purging—In installations where purging is necessary, the purge fluid may be injected at the top of the extension tube (Figure 2) or at other connections provided in the instrument. Where the main line pressure or purge fluid supply pressure may vary over a period of time, it is advisable to use a purge rotameter-differential regulator combination for automatic control of purge flow rate.

Startup—When putting the rotameter in operation, the block valve(s) should be opened slowly to prevent flow surges which might damage the float or other meter components. If the meter is purged, the purge flow must be started first.

What Eddy Currents Reveal About Metals

THE GIST: An ac coil held near a piece of metal causes eddy currents to be induced in the metal. These currents, in turn, cause a slight change in coil voltage which may be analyzed to indicate the content, condition, and properties of the material. In this article the author explains the many ways that this voltage change can be made to yield metal information, not only for test purposes but for process control loops as well.

RICHARD HOCHSCHILD
Metrol, Inc.

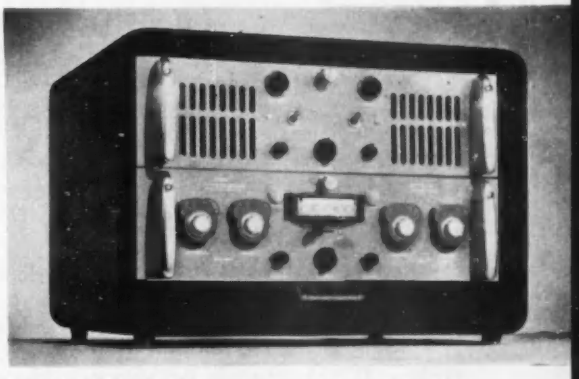


FIG. 1. RADAC eddy current test instrument contains frequency generator plus amplifying and filtering networks for screening return signals.

Many physical and metallurgical variables affect eddy currents in metals. Among these are:

1. Physical shape, external dimensions, and thickness
2. Distance between part and electromagnetic coil
3. Plating or coating thickness
4. Chemical composition
5. Distribution of alloying or impurity atoms. This is influenced by heat treatment of part and, hence, may be used as a clue to hardness, strength, phase, grain size, etc.
6. Lattice dislocations caused by heavy working or radioactive bombardment
7. Temperature
8. Discontinuities, including most types of flaws
9. In ferromagnetic metals, residual and applied stresses

In practice, many and sometimes all of the factors listed may vary simultaneously. Obtaining a meaningful response under such conditions is undoubtedly the most difficult problem associated with eddy current techniques because all of the information about the test part is transmitted to the coil or probe by the magnetic flux set up by eddy currents. The resulting voltage, which is the parameter sensed by eddy current instruments like that in Figure 1, must be carefully analyzed to isolate the sought-after effects from the extraneous. Fortunately an alternating voltage contains three independent pieces of information, not just one. It has amplitude and phase and contains a variety of frequencies. The control engineer has available to him a number of techniques that make use of all of this information and permit him to discriminate between test variables to a considerable extent. The important techniques are phase analysis, modulation analysis, special coil designs, choice of test frequency, and magnetic saturation.

Phase analysis

This type of analysis involves measurement of the phase shift between test coil current and voltage, due in part to the time it takes for an electromagnetic signal to get to different depths in the metal and out again. The phase velocity v of electromagnetic waves in a conductor is

$$v = \sqrt{\frac{2\omega}{\sigma\mu}}$$

where $\omega = 2\pi f$
f = test frequency
σ = conductivity of the metal
μ = permeability.

The velocity of electromagnetic waves in conductors is far less than their free-space velocity of

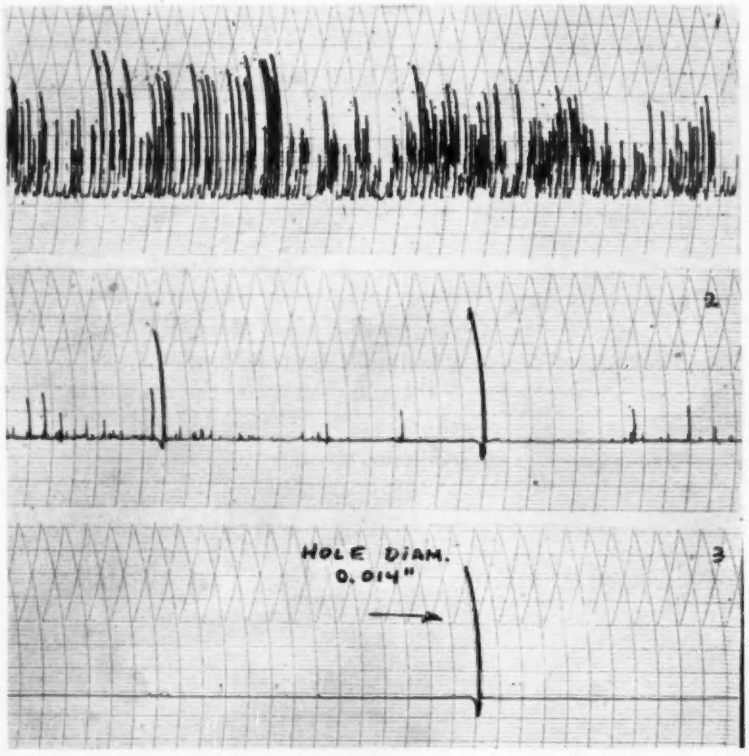


FIG. 2. Recorder charts show signal display for three different degrees of modulation.

3×10^{10} cm per sec. For example, the velocity in copper at a frequency of 10^6 cps is 4.1×10^4 cm per sec. At 10,000 cps in the same metal it is only 4,100 cm/sec, and at 100 cps the velocity is down to 410 cm/sec. At such relatively low velocities, phase lags caused by travel of the signal through the metal are easily measured.

Prior work with phase analysis has shown that it uncovers some vital information about metals. For example, the presence of a flaw will cause the voltage produced in the test coil to lag; flaws at different depths produce different phase lags. Homogeneous small changes of conductivity, which affect currents at all depths, are found to produce voltage signals with some unique intermediate phase lag. Small permeability variations yield signals at still another unique phase angle because they affect the magnetic induction rather than the currents directly. The same is true of small dimensional variations in the part or small variations of the position of the test coil relative to the part.

Some of the resulting analysis possibilities are immediately evident. It should be possible to distinguish between flaws at varying depths and to detect conductivity, permeability, and dimensional variations by noting the phase of the voltage signals. Although there are some practical limitations to the applicability of phase sensing methods, they have proven to be some of the most useful among the techniques of signal analysis.

Modulation analysis.

When electromagnetic tests are carried out by scanning the part continuously with the test coil, the test coil voltage is "frequency modulated" by variations in the part. The voltage frequencies generated in the coil depend on the velocity of the relative motion and the spatial distribution of the test-part variables that cause the modulation. It is found in general that discontinuities such as cracks, seams, holes, and inclusions produce relatively high modulating frequencies. In contrast, frequencies associated with residual stresses and dimensional variations tend to be intermediate. Still lower are frequencies associated with composition, heat treatment variations and temperature drifts.

The RADAC instrument, Figure 1, employs a system of adjustable filters to reject certain modulating frequencies in the test signal and pass other frequencies. In this way two channels of information, designated as differential and absolute, are produced. The differential channel contains high-pass filters and thus is sensitive to discontinuities but not to gradual conductivity, heat treatment, or temperature variations. How this circuit, properly adjusted, selectively passes flaw information is illustrated in Figure 2, which shows three recorder charts taken on the same piece of tubing with the high frequency filters adjusted in three different ways. The tube was made of 304 stainless steel, had an unusually high residual stress content, and contained one flaw, a 0.014-in. diam drill hole.

At the filter setting used to produce the upper chart, the differential channel allows stress effects to pass through the detection system. The flaw response is lost in the forest of stress responses. Much of the stress response disappears when the filter is set to a higher cutoff frequency, as was done for the center chart, where the response to the hole is clearly visible. However, there is still some reaction to variables other than discontinuities, making valid identification difficult. Finally, at a still higher cutoff frequency, other extraneous responses disappear, and the only response remaining on the chart is that due to the flaw. Essentially identical results are obtained for notches and most other types of

artificial and natural discontinuities.

In contrast to the differential channel, the absolute channel contains low-pass filters. Thus it is responsive to slowly changing variables such as composition, heat treatment, dimensions, and temperature. Most flaws do not show up in the output of this channel unless they are exceptionally large.

Simultaneous use of phase and modulation analysis increases the possibilities for detecting variables. Often one method alone is incapable of adequately suppressing extraneous factors—severe stress effects for example. But these can often be isolated if both phase and modulation settings are manipulated.

Test coil design.

The information entering an eddy current test apparatus depends largely on the design of the test coil system, i.e., the coil and its associated circuit. Proper designs and combinations can be made to perform highly specialized tasks. But the control engineer should be cautioned against looking for universal systems. For example, a coil system designed for conductivity measurements should hardly be considered ideal for the detection of flaws.

Test coils have miscellaneous shapes, Figure 3. Their physical dimensions, distance from the part, the possible use of shielding materials, and the test frequency determine the part volume that influences the test at any instant. When it is desired to resolve small flaws, this volume should be as small as possible so that the flaw occupies a relatively large portion of it. Where the object is to measure conductivity, the volume should be large to minimize the effect of flaws and surface irregularities.

Flat test coils coupled with fast response circuitry are generally desirable for high resolution eddy current flaw detectors. The longer an encircling coil is, the poorer is its ability to resolve highly local conditions in the metal. Where differences, such as alloy or heat treatment variations or very long cracks, extend over appreciable areas of the part, and where the detection of highly local conditions or small flaws is not desired, deep coils are effective. On the other hand, coils as shallow as 0.03 in. have been used to detect flaws of similar length. Flat annular coils have another advantage. At the ends of a rod or tube there are blind spots, roughly equal in length to the coil, that cannot be tested. Thus the flatter the coil, the smaller the blind spot.

Choice of test frequency

Because of skin effect phenomena the value of test frequency determines the depth of penetration of electromagnetic fields and eddy currents into the specimen metal. At relatively low frequencies, fields and currents penetrate more deeply. At higher frequencies they are limited to a thin layer just beneath the surface of the metal so that the condi-

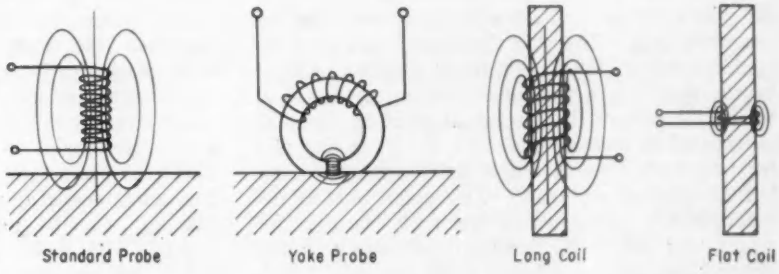


FIG. 3.
Four common types of probe configurations.

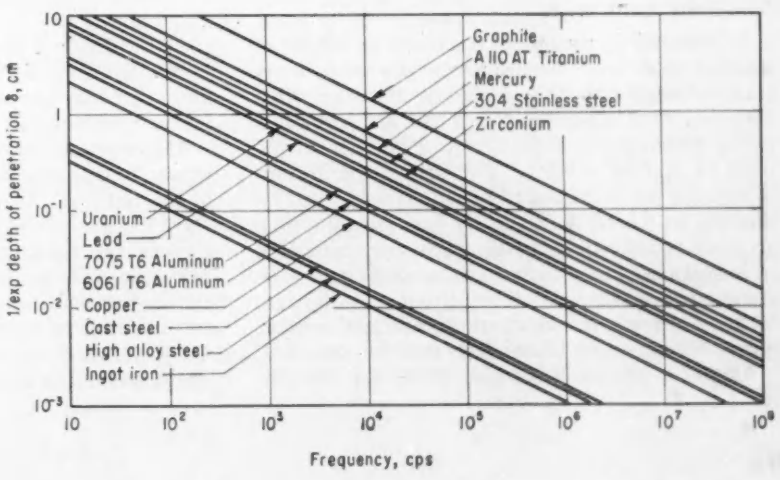


FIG. 4
Penetration vs frequency for various types of metals.

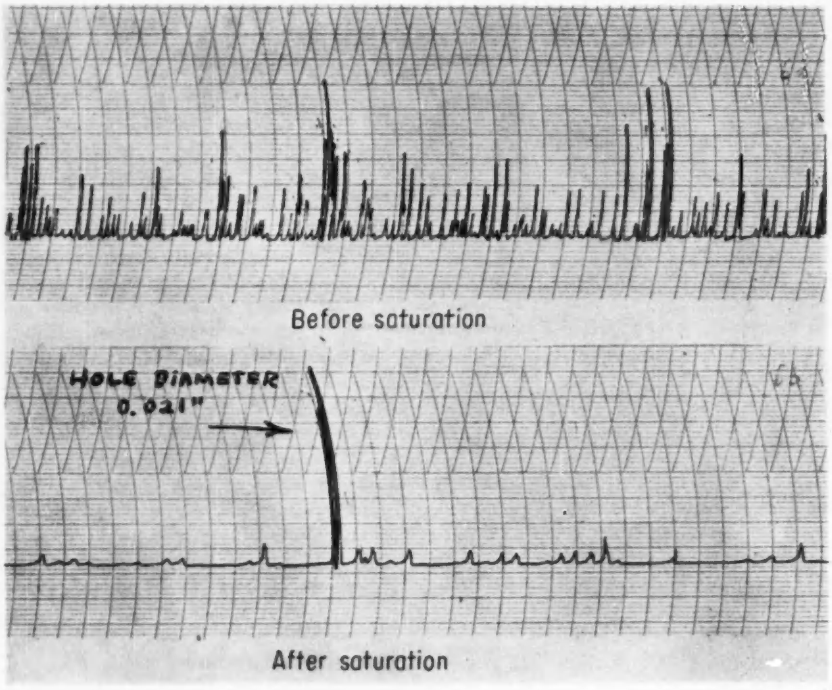


FIG. 5.
Charts show use of saturation to suppress extraneous signals.

tions of deeper sections cannot be investigated. The phenomenon is important in eddy current testing because it determines the relative sensitivity with which different regions of the test part can be probed.

Actually there is no skin thickness below which eddy currents do not flow, because such currents do exist in all parts of a conductor in an ac electromagnetic field. The skin depth or depth of penetration δ defined for plane waves is simply a measure of the depth in a semiinfinite plane conductor at which the current density has dropped to about 37 percent of its surface value. Figure 4 is a plot of δ for frequencies between 10 and 10^8 cps for a number of different materials. This graph aids in the determination of the test frequency to be used for a particular test. Note that the depth of penetration depends not only on frequency but also on the conductivity and permeability of the material.

Magnetic saturation

In tests of ferromagnetic metals, the effects of residual stresses on the instrument are often many times stronger than those due to flaws or other variables. The reason for this is that the permeability of ferromagnetic substances is a function of residual or applied stresses. The equipment in turn is sensitive to permeability variations and thus, indirectly, to stresses. In slightly ferromagnetic metals, such as 300 series stainless steels, the application of modulation analysis generally is sufficient to overcome stress effects. However, this is not the case for most strongly ferromagnetic metals, and another means of suppressing stress effects must be employed.

Magnetic saturation is highly useful for this purpose. The charts in Figure 5 show the recorded output of the differential channel of the RADAC instrument, Figure 1. Both were taken on the same steel tube containing a 0.021-in. diam drill hole. The upper chart shows the stress effects when saturation is not used. The response to the hole, if it exists at all, cannot be distinguished from the stress responses. The lower chart was taken with the test area magnetically saturated. The stress response has been suppressed to the extent that the signal to noise ratio for this size drill hole is at least 10 to 1.

Another useful by-product of saturation is the ability to make the inspection penetrate into ferromagnetic metals at normal test frequencies (1 to 100 kc), thereby retaining the greater sensitivity possible with higher frequencies. When the material is not saturated, the depth of penetration into typical ferromagnetic steels at different test frequencies is given approximately by the line labeled "high alloy steel" in Figure 4. When saturation is used, the depth of penetration is given approximately by the line labeled "304 stainless steel". Note that saturation may increase the depth of penetration in ferromagnetic metals by as much as 30 times.

Magnetic saturation is achieved by applying a very strong dc magnetic field to the test part in the area of the test coil. In the case of tubing this is done with the aid of two strong electromagnets which encircle the tube on either side of the test coil. Saturation coils are normally several inches in diameter and several inches long and dissipate from several hundred to several thousand watts. The size and power consumption of a saturation unit depends on the amount of metal to be saturated with it.

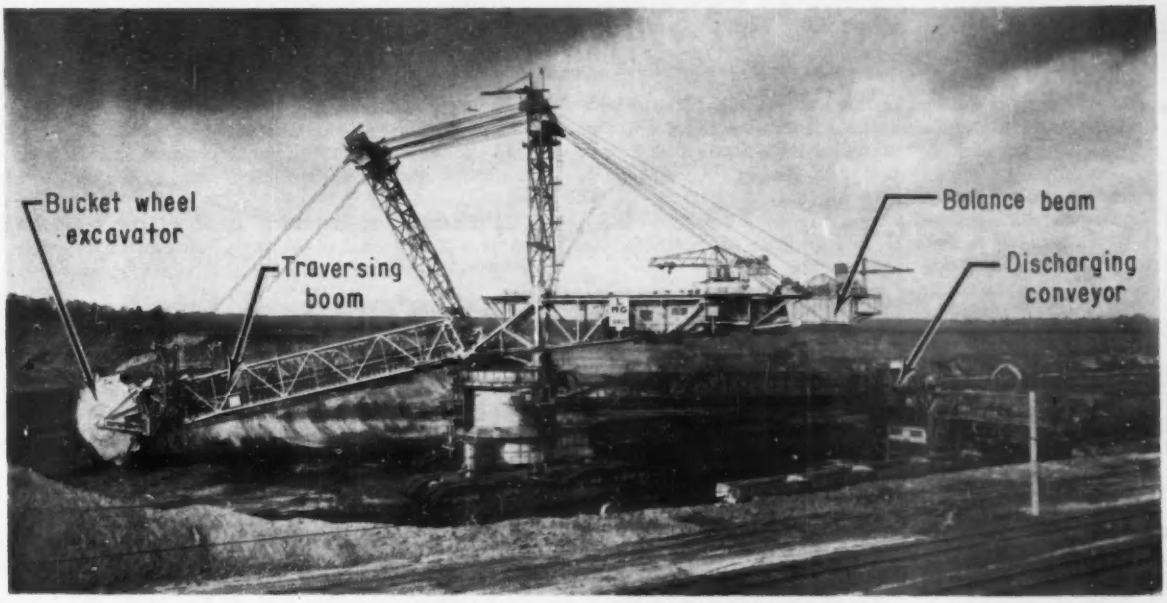


FIG. 1. Huge coal digger dwarfs man hardly visible at front of rear crawler.

Tiny Electronic Controls Run
Giant Coal Digger

A. THEUER and G. LENHARD
Brown Boveri and Cie. (Germany)

Two electronic information systems have made control of a huge excavator automatic. Digital techniques—applied with decade counters—are used in an automatic positioning sytem. An analog computation circuit calculates and regulates the speed of traverse automatically.

To make open pit mining a continuous operation, two subsidiary operations are added to that of digging: carrying the ore from the workface and then discharging it into railroad cars. Germany's largest—and possibly the world's largest—bucket wheel excavator has turned coal mining into a continuous operation directed by an automatic speed and position control. The giant 6,300-ton coal digger (Figure 1) can chew out and discharge 130,000 cu yd of material a day. Digital positioning techniques regulate the depth of cut and program the machine's forward motion which is governed by resolver computations.

Three main units make up the continuous miner: an excavator with 10 cutters on a 53-ft diameter rotating wheel, cutting 63 cu ft of coal every 1.5 sec; a conveyor system to carry coal from the cutter, discharging it through the center assembly of the machine; and a second conveyor system, located on an intermediate gantry, to transport coal to the loading terminal from which it is discharged into passing railroad cars. Both the excavator and the loading terminal move on multiple tracks as the coalface is mined.

Everything about this rig is huge. A tracked vehicle, powered by nine 136-hp motors, carries the 6,300-ton digger. Above the carrier is a ring which connects the two conveyors; the ring is free to rotate as the excavator moves forward. Completing the rig, a superstructure carries a 270-ft boom to which the cutter is attached and another boom-like structure that contains a balance beam at the rear. The main superstructure can rotate through 360 deg.

At the start of an automatic mining cycle, the digger is positioned so that the digging bucket engages the coalface at a point where the boom supporting the digger lies at right angles to the direction of motion of the tracked carrier. As the bucket digs, the boom and structure slowly rotate, moving through an angle of

180 deg. At the end of this traverse, the carrier vehicle advances the entire mechanism the length of one cut. The boom and superstructure then slowly rotate back towards the starting point. All during this movement, the bucket continues to dig coal. When the digger reaches the end of a proposed series of cuts, the control is switched to manual, and an operator positions the excavator for a new series of cuts.

Because a constant extraction rate has to be maintained, a second subsidiary system controls the traversing speed (of the boom) which is speeded up or slowed down depending on the angle the bucket wheel makes with the direction of motion. Speed of traverse is inversely proportional to cosine angle ϕ (Figure 2), the angle between the direction of advance and the boom. Traversing speed is increased as the area of the 10 cutters engaging the coal face decreases.

Figure 3 illustrates how the major parts of the two control systems go together to

1) Advance the coal digger a programmed distance in a series of discrete steps, each equal to the depth of one cut.

2) Control the traversing speed of the boom so that it is proportional to the angle between the direction of forward movement and the coal cutter boom.

DIGITAL POSITIONER

Digital counting techniques are the key to forward movement control. The required depth of cut and the length of the excavator's forward travel have to be inserted manually. The same control programs the logical sequence of both the swiveling and forward motion of the machine.

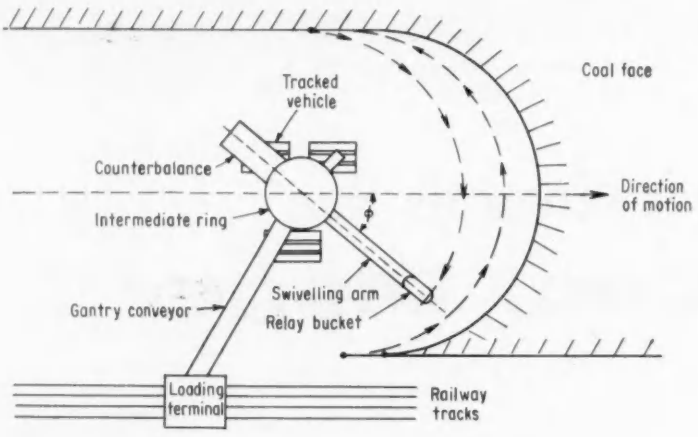


FIG. 2.
Diagram shows how digger mines coal face.

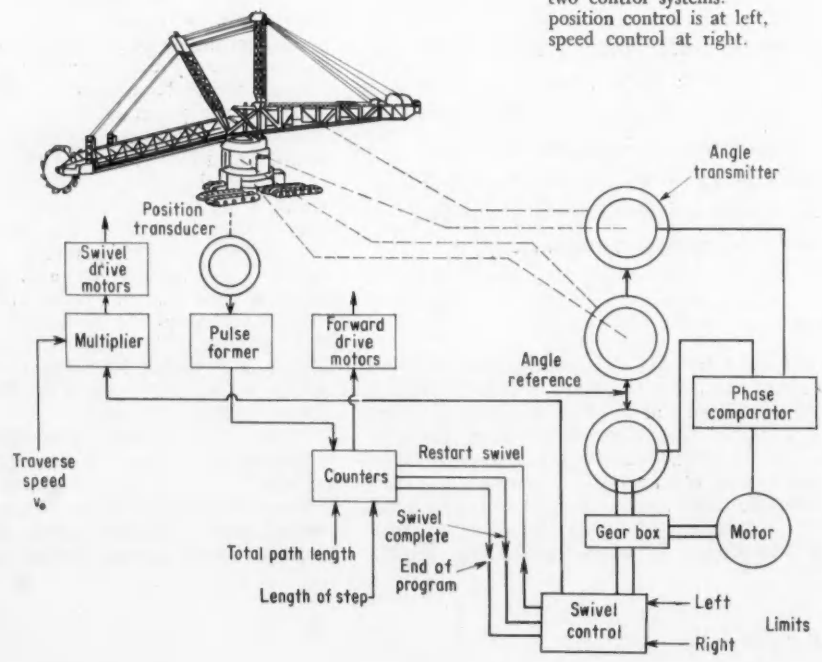


FIG. 3.
Block diagram of the two control systems: position control is at left, speed control at right.

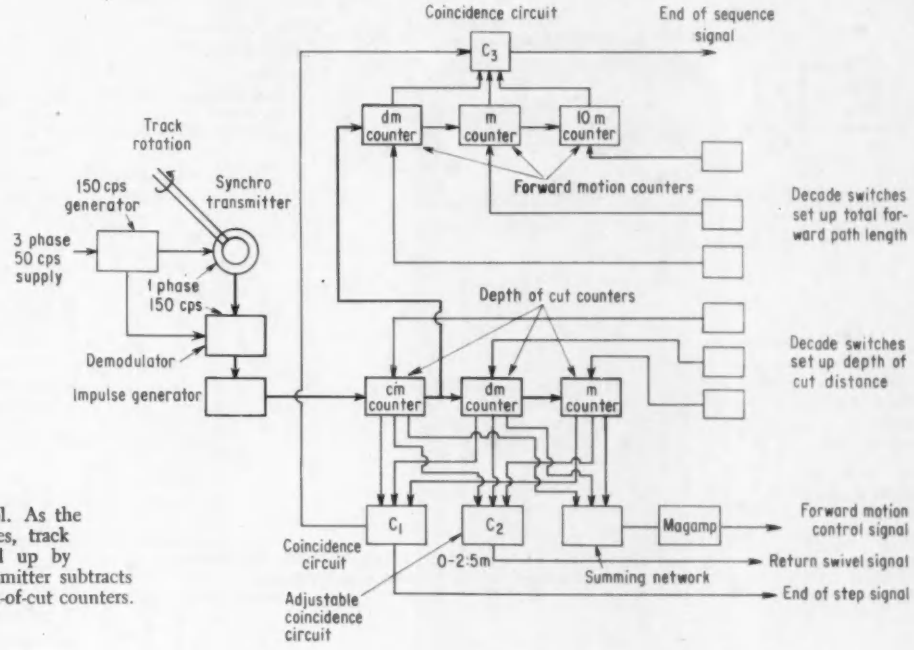


FIG. 4.
Position control. As the vehicle advances, track rotation picked up by a synchro transmitter subtracts from the depth-of-cut counters.

When the cutting boom reaches the end of its traverse, it closes a limit switch to trigger a counter unit which allows the machine to advance the preset depth of cut. As the excavator travels forward, a synchro coupled to the vehicle's tracks sends a signal to step the counter from a preset value toward zero. When this depth-of-cut counter records zero, forward motion ceases, and the boom swiveling motors are energized to start the boom on its reverse cut.

Simultaneously the amount of forward movement is subtracted from a second counter which has been preset to the total length of cut. When both counters are reduced to zero, all further forward motion stops.

COUNTING STEPS

How these counters work together can be seen in Figure 4. There are two sets of three-decade decimal units in each counting circuit. In the depth-of-cut system, the centimeter is the basic unit; the counter registers centimeters, decimeters, and meters (as shown in Figure 4). In normal mining, depth of cut may vary from 0.3 to 2.5 meters. Length of path counters register decimeter, meter, and 10 meter decades. Forward lengths are set from 1 to 50 meters.

Size of the depth of cut can be changed during mining. To permit this the input from the decade switches is passed to the counter only at the end of the boom's traversing motion. A limit switch actuated by the boom mechanism transmits a triggering pulse which sets the depth-of-cut counter to that which has been programmed. As soon as the count is registered, a signal proportional to the distance to be traveled energizes the speed control circuit in the motor drive system to start the forward motion.

Vehicle movement is fed back from a synchro transmitter coupled to the vehicle drive. Each centimeter of travel phase shifts the 150-cps field one complete cycle. A ring demodulator detects the amplitude modulated signal and feeds an impulse generator whose output—a chain of pulses each corresponding to a movement of 1 cm—triggers the centimeter decade on the depth-of-cut counter.

Each decade of the reversible counters consists of 10 ring-connected cold cathode tubes. Output voltages of the cathodes are proportional to the instantaneous count. Each pulse received from the synchro transmitter (through the demodulator and impulse generator) subtracts from the initial depth of cut inserted in the decade switches. Cathode outputs are then summed in a mixer unit to generate a control signal proportional to the distance still to be traveled. To maintain a slow creep speed of 4.3 ft per min, even at final approach when the error signal is too small to position the heavy excavator, a magnetic amplifier superimposes a small dc voltage signal on the distance proportional error signal.

COINCIDENCE CIRCUITS

An auxiliary coincidence circuit (C_1 in Figure 4) stops the forward drive motors. It is connected to each of the "zero" cathodes in the three decades. When all decades reach zero, a stop pulse halts the motors.

A second coincidence circuit (C_2 in Figure 4) starts the boom on its return cutting trip. It too is connected to the three decades of the depth-of-cut counters. It has an adjustable triggering point (between zero and 2.5 meters) and starts travel when preset point is reached.

While the excavator is moving forward to the next cut, every tenth pulse from the centimeter decade on the depth-of-cut counter feeds to the forward path counter. Such pulses subtract from the total path length which has been stored in the forward motion counter. A visual indication of the length traveled appears on a control console in the operator's cabin.

CHECKING CIRCUITS

Two checking systems insure accurate counter operations. One verifies the sequential operation of the

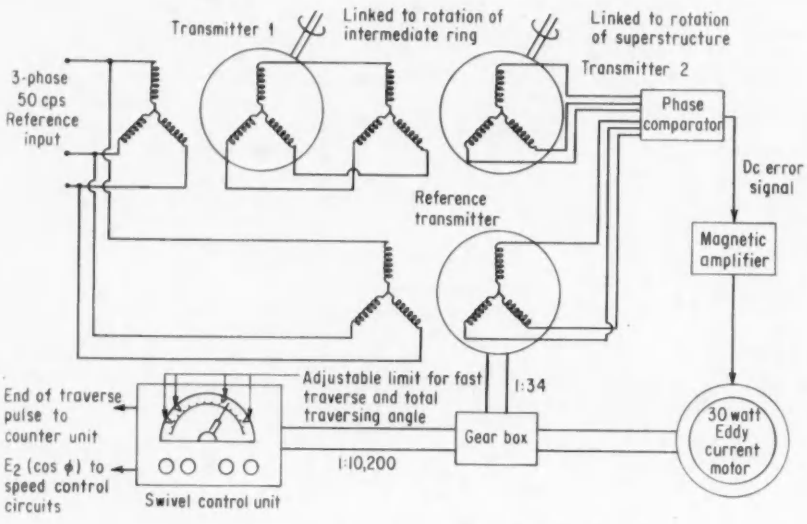


FIG. 5. Two-stage resolver system determines the angle to which speed is proportional.

depth-of-cut counter; the other shuts the system down if it overruns the zero point by more than 5 cm.

Sequential checking is carried out on a binary basis. In the depth-of-cut counter all cathodes of the centimeter decade are connected to diode OR-matrices. Which of two matrices is energized depends on the condition of the decade: odd or even. Alternate odd and even outputs switch a bistable flip-flop; at the same time the distance transmitter demodulator feeds a train of pulses into a second bistable flip-flop. The flip-flop states are compared by an AND circuit; coincidence represents a missed pulse, shuts off forward drive motors.

As protection against overrunning, a subsidiary counter shuts off the drive motors if the depth-of-cut counters pass through zero and it adds up a positive count of five centimeters past the null position.

CONTROLLING THE BOOM SPEED

When the bucket wheel digs along the line of movement of the rig, each cut removes the maximum amount of coal. As the bucket wheel moves away from the position normal to the coal face, effective cutter area decreases. To maintain the required flow of mined coal, a control automatically increases the traversing speed of the boom. Boom speed is expressed by the relation:

$$v_\phi = \frac{v_o}{\cos \phi}$$

where v_o = traversing speed when angle between forward motion of excavator and boom is zero
ϕ = angle between forward motion of excavator and boom.

Since there is no mechanical linkage between the tracked vehicle and the superstructure—because of the rotatable intermediate ring—a two-stage resolver system determines the angle between them indirectly (Figure 5). A differential transmitter first determines the angle between the tracked vehicle and the intermediate ring. The transmitter's stator windings, energized from a three-phase 50 cps supply, produce an output which has been phase advanced by an amount proportional to the angle of the ring relative to the vehicle. This signal is then applied to the stator of a second differential transmitter mounted between the intermediate ring and the superstructure. Phase comparison of the output of the second transmitter with a reference signal provides a measure of the angle between the superstructure and the direction of motion. A self-balancing servosystem generates a mechanical output proportional to this angle.

The phase difference between the output of the second transmitter and the reference signal produces a dc error signal whose polarity represents the direction of the difference. The error signal, fed through a magnetic amplifier, controls the direction of rotation of a 30-watt eddy current disc motor, driving the rotor of the reference transmitter through a gear train to a phase difference null. Finally a pick-off on the gear train feeds a shaft position proportional to the boom angle ϕ to the boom traversing control.

To control boom traversing speed as an inverse function of the cosine of the boom angle, a voltage proportional to $v_o/\cos \phi$ is formed in an inverse multiplier circuit which controls the speed of the traversing motors. A synchro coupled to the indicator drive in the control unit generates a voltage proportional to cos ϕ; a potentiometer selects the nominal traversing velocity v_o. This proportional voltage is obtained by inverse multiplication, achieved by connecting a multiplier circuit—two saturable reactors with a diode switching reactor—as the feedback in a high gain magnetic amplifier.

The multiplier output function of $E_1 v_o/E_2 \cos \phi$ is fed directly to the motor drive circuit, controlling the speed of the two 163-hp dc shunt-wound swivel motors. These dc motors are connected in tandem to rotate the superstructure and are energized in a simple series loop Ward-Leonard system from a single 358-hp generator driven by a six-pole, three-phase induction motor. Generator field excitation is supplied by a variable voltage exciter unit.

A closed-loop voltage control system regulates the motor speed in proportion to the function generated by the multiplier unit. Feedback from both generator armature voltage and current is amplified in magnetic amplifiers, and the resultant signals are summed to compensate for the generator IR drop. After comparison with the set speed voltage $E_2(v_o)$, the error signal energizes the exciter fields through two push-pull magnetic amplifiers. Generator armature current signals fed back directly to the system give current limitation.

A secondary field coil on the generator provides feedback to the exciter for acceleration limitation in a subsidiary control loop. System stability is assured by flux change feedback from a tertiary field.

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5 Case Studies Show Efforts to Simplify Maintenance

As control systems become more complex, user acceptance depends in part on maintenance ease. A previous article (CtE, August 1959, pp. 73-78) described ways to simplify trouble-shooting and repair, varying all the way from the simple concept of modular plug-in construction to complex automatic test routines designed to pinpoint the trouble area. The following case histories show how these techniques have been applied by a sampling of control equipment suppliers.

BYRON K. LEDGERWOOD, Control Engineering

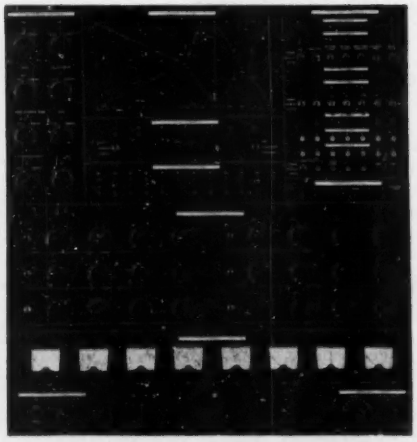
CASE HISTORY 1
A data-logging system

Figure 1A shows the checkout panel of a Beckman 210 data-logging system. All fuses have neon blow indication, and the fuse holders have a small hole in the center that permits checking the voltage at the load end. The latter is important, for excessive drop across the fuse may indicate excessive current drain. Note the meters on all power supply voltages and the marginal checking provisions in the lower right-hand corner. The voltage can be regulated to selected modules to pinpoint the difficulty through marginal checks.

Every flip-flop in the system has signal lights directly connected to the transistor circuitry and mounted on the front edge of the plug-in printed circuit boards. These lights are arranged to burn dim during an OFF condition and brightly during an ON condition. This avoids the high current transients that would occur if the lights were switched completely on and off. Test points for making voltage or waveform measurements are also included on all printed circuit boards.

One of the most interesting features is the control states panel shown at the top-middle of Figure 1A and schematically in Figure 1B. The indicating lights on this panel graphically display the status of the system's logical circuitry by lighting in a definite sequential pattern that depends on the operating mode. As shown by the arrows, there are six operating modes: start, tape record, end of block, end of tape, stop, and printout by electric typewriter.

Under normal operating conditions the indicating lights on the control states panel are changing too rapidly to be observed. For maintenance purposes, it's possible to place the machine in any one of the several operating modes, and to operate it on a manually pulsed basis. Failure of an indicating light to properly transfer at any point indicates problems in the interconnecting circuitry.



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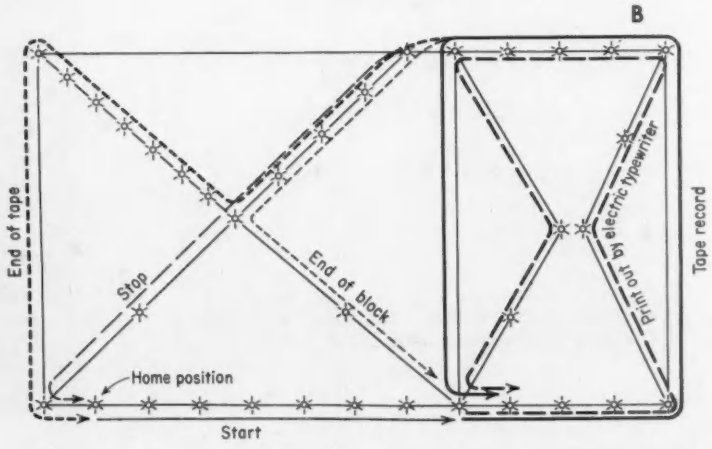

FIG. 1. Beckman 210 data logging system has many trouble-shooting features. A shows operating and checkout panel, B the operating modes on control states panel.

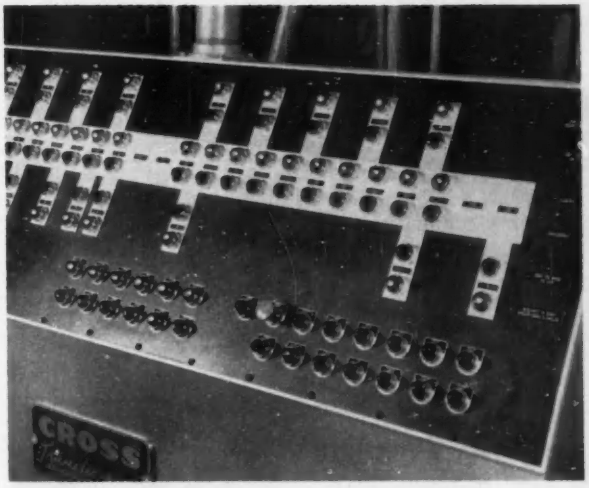

FIG. 2. Indicating lights laid out in form of machine pinpoint trouble area.

Graphic Panel
Applied to a Transfer Machine

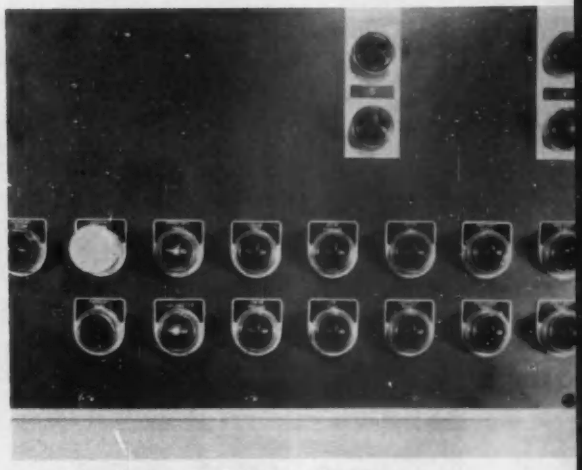

FIG. 3. Auxiliary-function faults are indicated by separate indicating lights.

CASE HISTORY 2
A transfer machine control system

Some interesting trouble-shooting advances by The Cross Co. were described by Frank Boledovich at a Westinghouse Machine Tool Forum (Ref. 1). Figure 2 shows part of the control console of a Cross transfer machine: indicating lights tracing the cycle condition of the various heads and clamps making up the basic machine are displayed in their appropriate position within an outline of the machine. In this way, the sequence of machine operations can be easily followed and the general area of malfunction located. A failure in auxiliary or service devices —those devices that are not a part of the machine proper and have no direct relationship to the machine cycle, such as automatic lubrication systems, coolant systems, and chip conveyors—usually requires machine stoppage. Therefore, they must be interlocked with the basic machine control circuits. One light per device will usually serve to monitor these systems, Figure 3.

CASE HISTORY 3
A steel mill programming system

Next consider a GE card-programmed controller which might be used to automatically adjust the opening between work rolls, select mill roll speed and direction, and control the direction of table roll on a blooming mill. Figure 4 shows the control panel (note most of the equipment is accessible from the front), the open-channel wiring, and the static switching elements with integral indicating lights.

Figure 5 shows a portion of the circuits used to read a punched card in this system. There is one readout circuit for each card column and diodes for the required isolation between horizontal rows. Relay interlocks energize rows at the proper time. The 960 reading circuits make circuit checkout a difficult project, but a semiautomatic test procedure takes care of it. Here is how it works: If no card is in the reader, all brush circuits should make contact; then, selecting one row at a time, a signal should be obtained on each readout circuit. The indicating lights show whether or not these signals are present. If all of them are, the row being tested checks out. If any light is not on, the associated circuit is known to have failed open. By reversing the supply voltage and repeating the test sequence row by row, the diodes can be checked for blocking. If any light comes on during this test, the associated diode has failed shorted. Figure 6 shows the card test panel.

There are other automatic test features in this equipment. One circuit tests the interlocks in the reference circuit of the position regulator, all of which are subject to wear. Upon initiation the circuit automatically selects, tests, and passes on to the next interlock, until all interlocks have been tested. If a fault is detected, the test stops and trouble is located by the pattern of lights. In addition, there are pushbuttons that initiate the procedure for sequence-testing the static stepping ladder and the static pulse generator.

The system also has a semiautomatic test for the output amplifiers, based on instrumentation built into the amplifier. A manually controlled tap switch injects signals into various modules of the amplifier, from output towards input. Failure of output instruments to read the correct value means a defective module; it is indicated by the position of the test

Steel Mill Downtime
Must Be Prevented At All Costs

FIG. 4. Static switching elements with indicating lights in GE mill control panel increase reliability and speed maintenance.

switch. This provides a rapid operational check of the entire regulating amplifier.

Probably 90 percent of the troubles that might occur in the information handling and electronic portions of this mill control system can be located by the above test routines (Ref. 2).

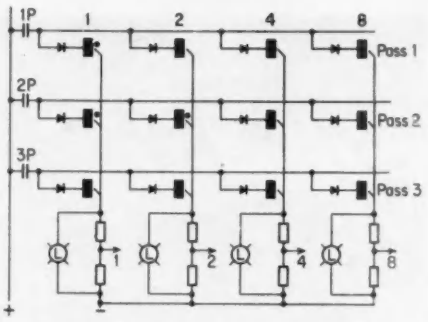

FIG. 5. Semiautomatic procedure checks out card reader in mill programming system.

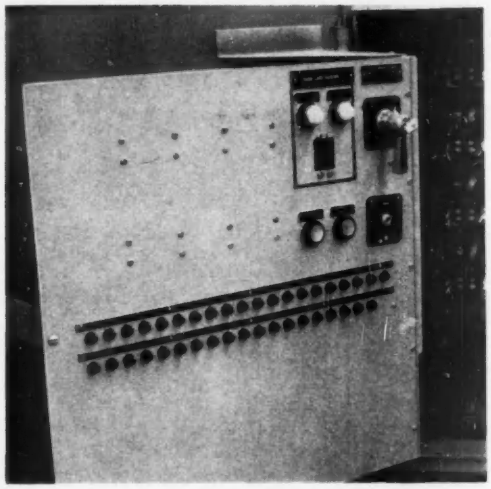

FIG. 6. Faults in card reader are indicated on light panel.

CASE HISTORY 4
A machine tool numerical director

Moving into the area of continuous-path numerically controlled tools, consider the Numericord Director System designed and built for Giddings & Lewis by Concord Control, Inc. This special purpose digital computer takes point-to-point coordinate information describing the path to be machined and cutting-rate information from punched tape, interpolates it linearly, and records the output on magnetic tape as phase-modulated square-wave signals.

Figure 7 shows the director system. The unit on the left houses the power supplies. Provision is included here for marginal checking, gradual increase of filament voltages through a motor-driven autotransformer to prevent tube burnout on starting, and ac and dc trouble lights. The center cabinet contains the control panel, tape-input equipment, and the main data processing portion of the director system. The three doors open on racks of plug-in modules, each consisting of printed wiring boards with neon indication of the status of the element. Vertical cooling ducts are provided. Slide-out panels are used where required for accessibility, and contact arrangements of telephone-type relays are next to the relay bank for easy reference. Low cabinet houses the magnetic tape recorder (Ref. 3).

The main trouble-shooting aids in this system are the annunciator lights, located inside the right-hand side of the director and keyed to critical portions of the equipment. When the trouble light on the front panel lights, the operator or maintenance man refers to the annunciator panel shown in Figure 8. The following is a rundown on the alarm functions:

1. Storage system—Something is wrong in the transmission of information from tape to the storage system; say, a shorted tube has blown a fuse.
2. Axis-reverse—The director system is designed to make mirror-image parts by throwing the axis-reverse switches. But if this switch is thrown, the operator must hold down the start button twice as long as he usually would. If he doesn't, the alarm lights. This prevents making mirror-image parts accidentally.
3. Decoder—Malfunction in the decoder section.
4. Record current—Monitors the recording current when auxiliary function commands are being recorded on magnetic tape, making sure recorded signal is of sufficient amplitude.
5. Recorder lid—Recorder cabinet lid interlock.

Lid must be closed during entire recording period or it is invalidated.

6. Tape tension alarm—Indicates that the magnetic tape is broken, loose, or improperly threaded.

7. Clock system—Indicates failure in the system.

8. Playback signal—This monitors the axis-motion signals recorded on tape by playing back and actually measuring the strength of the recorded signals.

9. Tape error—Indicates tape code is unacceptable or unperformable commands have been received.

10. Incomplete read—Indicates that the tape reader has not finished reading a command when the director needs it. This can occur if the paper tape reader is not running as fast as it should (because of belt slipping, for example).

11. Incomplete program—Power is turned off before the director is finished recording a program.

12. Power supply—Indicates any type of power-supply failure.

In addition to these permanent alarm indicators, there are test tapes that have proven their value as trouble-shooting aids. The general technique is to hold all but one variable constant on each tape and use them in conjunction with the above alarms and with marginal checking systems. Two typical tapes are as follows:

1. Tape runs director at each of the possible command times for a cut: 0.5, 2.0, 5.0, 10.0, 20.0, etc. sec. It should process all commands properly. A failure on 2.0, 20.0, and 200.0 sec pinpoints the trouble by indicating consistent failure in the two digit.

2. Tape puts system into five-axis mode and supplies same commands to each axis: 0.0005, 0.001, 0.002, 0.005, 0.010, etc. in. Strokes are obtained by combining smaller commands. Thus an 18-in. cut is obtained by adding 10, 5, 2, and 1. Checking output of director on the axis position indicators makes it possible to analyze the combinations and manner of failure, and thus locate trouble.

FIG. 7. Numericord Director System, designed and built for Giddings & Lewis by Concord Control, Inc.

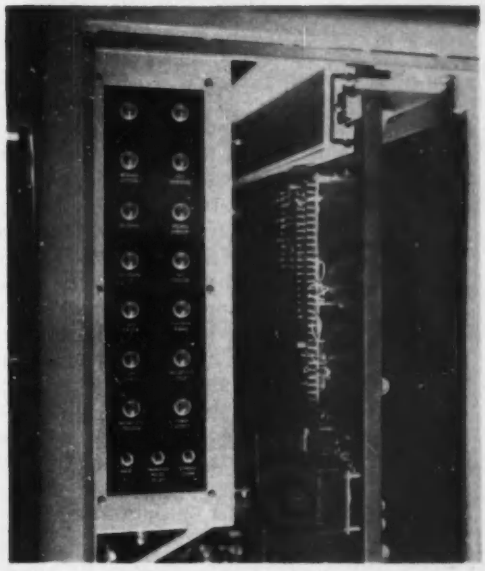

FIG. 8. Alarm annunciator panel within the director spots trouble.

CASE HISTORY 5

An integrated machining system

In the G&L-Concord numerical control system the director containing almost all of the information-handling electronics can be located in a special room with an environment similar to that encountered by scientific and business digital computers and can handle a large number of tools.

In contrast the Bendix tape-controlled continuous path system—shown in Figure 9 on a K&T profiler at Republic Aviation—has no magnetic tape link, and the interpolating director is located on the factory floor next to the machine it controls. Thus all of the director electronics is exposed to the environment of the machine tool. The Bendix system differs from the G&L system in another way also: it measures relative position by generating a number of incremental pulses proportional to machine movement. These are compared to the number of director-generated pulses in a bidirectional counter and the difference is converted to an analog signal, amplified, and used to drive the hydraulic servovalves.

Considerable design effort was expended in making this system easy to trouble-shoot and easy to repair (Refs. 4 and 5). All logic circuits are in plug-in modules with color-coded handles and position-coded locating plugs. Care is taken to make sure that all heat-generating elements are properly cooled, and neon indicators are included to show the state of the logic elements. Open-channel wiring is used in the power-handling cabinet, and most active circuit elements are accessible from the front either through slide-out or swing-out construction.

Now consider some of the trouble-shooting in-

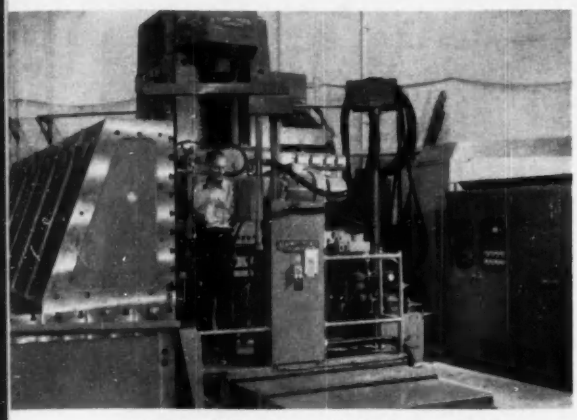

FIG. 9. K&T profiler with Bendix numerical control at Republic Aviation.

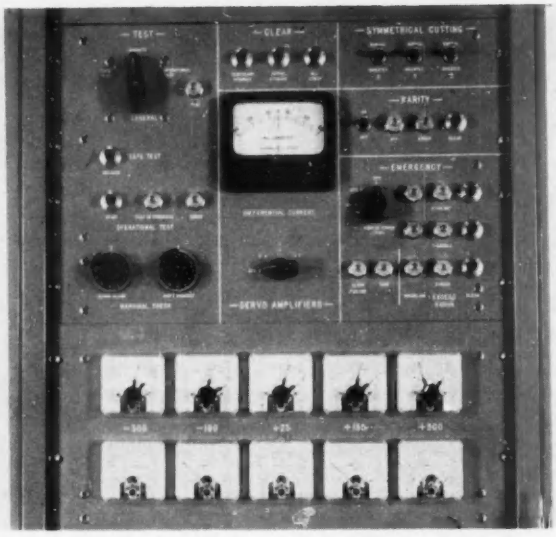

FIG. 10. Test panel includes many trouble-shooting features.

strumentation that appears on the control panel shown in Figure 10. The upper selector switch in the left-hand upper part of the panel permits selection of the normal operating condition, of the diagnostic tape routine, or of the operational test. The button below the switch advances the tape block by block, and the button below that starts the operational test. The test-in-progress light flickers under normal conditions and the error light comes on when there is a malfunction. The two dials on the bottom of this part of the panel are used to marginally adjust the clock clamp and the shift current during the test.

The buttons on the middle-top panel permit clearing pulses from the logic circuits when they contain false information. The meter and selector switch monitor the servoamplifier outputs on all three axes.

The top row of switches on the right-hand panel permits cutting mirror-image parts on the three axes. The row of switches and lights in the middle indicates errors caught by the parity check. The selector switch in the lower block selects the permissible count level in the excess error registers, while the lights to the right indicate excess error and error overflow in the three axes. The lower light, labeled "clock failure" goes on if the electronic clock circuit fails, and the one to its right lights if the tape overshoots a block of information or if the tape breaks.

The meters on the lower panel are hi-no-go/go/lo-no-go relay-contact meters that give a contact closure lockout if voltage is too high or too low. Each power supply voltage is monitored in this manner.

Bendix recommends four main diagnostic routines for regular or preventive maintenance: 1. Operational test mode to determine whether errors exist in the interpolator and error registers. 2. Tape test mode to check tape reading block by block. 3. Test tape for checking servosystem performance, interpolator, and tape reading. 4. A special battery box for checking servosystem performance independent of the machine control unit.

The operational test mode is a cyclic operation encompassing 80 to 90 percent of all the circuits. Most of the interpolator and servo circuits are made to operate in normal fashion, but the reader and its control circuitry are not used. By using the marginal controls, below normal operating conditions can be introduced during the test to help detect marginal components and intermittent failures.

The Bendix test tape contains eight tests used in diagnosing machine performance. Each test calls for certain motions to check different characteristics of the overall system, and each starts at a reference point and returns to the point at completion.

The first four tests program circles and squares in various planes. A dial indicator on the tool holder and the digital position indicators should check one another. If the position indicator returns to zero but the dial indicator does not, look for backlash or a marginal feedback loop. The next three tests program in rate step functions, varying the feed rate. The excess error setting and feed-rate override are adjusted as specified, and if an excess error occurs, the closed-loop performance of the machine is not satisfactory. The last test checks the operation of the interpolator.

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2. *A PUNCHED CARD PROGRAM CONTROL SYSTEM FOR THE STEEL INDUSTRY*, K. Reed Thompson, presented at short course on automation and computers, University of Texas, June 1958.
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Take a New Look at the Process Control Center

THE GIST: A considerable portion of the capital investment for process instrumentation is the cost of panels, controllers, recorders, and indicators installed in a control center. Control center design is therefore a good target for instrumentation cost reduction. In particular, the argument here is that on economic advantage may be had by separating the recording function from the controller function.

Furthermore, this advantage can be parlayed by minimizing the number of variables permanently recorded. Only those variables of significance during normal process operation need be permanently recorded. The other, nonpermanent, measurements can be recorded on multipoint recorders mounted on separate modules which, the author advocates, should be made available for leasing.

A. JAMES WALDRON
Catalytic Construction Co.

For both pneumatic and electronic instruments, a recorder controller costs $130 to $180 *more* than an indicating controller. Typical list prices: $375 vs $505. By separating the recording function, the total price differential can be appreciable, and depending on the number of recorded points, this differential can be used for buying and installing multipoint recorders in separate modules. To be specific, the analysis of savings resulting from separating recording from control will be based on the control center concept shown in Figure 1.

A breakeven point does exist below which separation cannot be justified. This breakeven point depends on several considerations which are best examined by discussing specific designs of recorder modules for three types of multipoint recorders, Figure 2 (p. 134):

CASE 1—Four-pen, large case, pneumatic recorders with 12-in. diam charts.

CASE 2—Three-pen, miniature, pneumatic recorders.

CASE 3—12-point, 12-in. strip chart potentiometer recorders.

(There are no three-pen miniature strip-chart electronic recorders available at this time.)

The table (p. 135) shows the cost of recording various numbers of points for the recorder arrangements in Figure 2. The 6-ft wide module appears to be a practical limit for a separate maneuverable module. In the table the total weights for the module are based on using $\frac{3}{16}$-in. steel plate, with open back and bottom. Of course the widths can be extended a few inches to suit a particular maker's model of instrument case. Line 3 of the table is the estimated total purchase cost of the assembled module, including piping and wiring to the wall-mounted junction box. Figure 3 summarizes the estimated cost per recorded point data taken from the table, line 4.

Some interesting facts emerge from a study of Figure 3 and the table. The top two curves of Figure 3 show that for pneumatic instrumentation the four-pen, 12-in. circular-chart recorder (Case 1) costs less per point than the three-pen, 4-in. strip-chart recorder, even though both instruments have the same accuracy and the same (4-in.) usable chart width. The lower curve, for the 12-point, 12-in. strip-chart potentiometric recorder (Case 3), shows a smaller cost per point than either of the pneumatic

recorders, a rarely mentioned argument favoring electronic instrumentation.

Figure 3 must be used with discretion, since the cost actually increases with the number of instruments needed and not the number of points used. For instance, recording 40 points requires four 12-point potentiometer recorders, and the total cost of the installation could be divided by 40 and not 48 to get a conservative per point cost; although it might be reasonable to divide by 48 if the eight spare points can be logically considered to have some dollar value, particularly for such future use as plant expansion.

Consider a typical example to determine the economic justification, if it exists, for separating recording from control. A plant has 30 control loops and it is assumed—in the first analysis—that each of the controlled variables must also be recorded. One alternative is not to separate the two functions. This might entail building a control panel with 30 individual, small case, recorder-controllers, each costing, say, $550. However, indicating-controllers of the same quality can be bought for $385, giving a price differential of $165 per instrument or $4,950 for the 30-point installation.

This cost differential is used as the basis of finding out whether the second alternative, separating recording from control, can be economically justified. Can the $4,950 buy a separate recorder module? The answer can be found by examining the cost data in the table. Assuming pneumatic instrumentation, the analysis is restricted to Cases 1 and 2. Under the column headed *3-ft wide module* it is seen that

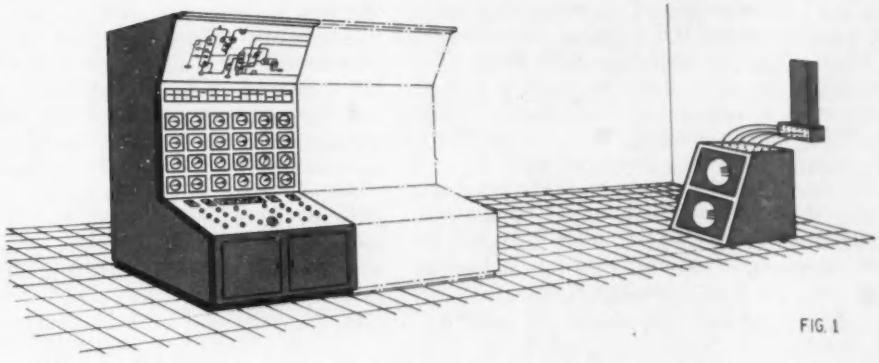


FIG. 1

A NEW CONTROL CENTER DESIGN

- *simplifies operator surveillance*
- *offers reduced investment for instrumentation*

At the left is a modular, semigraphic control panel; at the right is a separate recorder module. While human engineering studies indicate the Standard American Male can adequately survey a 6-ft wide control panel, a 4-ft wide module is suggested as a standard. Four feet allows up to 30 control loops in the continuous controller section of the module—an optimum for operator surveillance.

The layout of the controller section shows both deviation indicators and deviation indicating controllers, although both would not actually be used on the same panel. The shadowgraph indicator—with horizontal bar indicating direction and magnitude deviation of the variable from setpoint—would be used in conjunction with standard dial- or strip-scale indicating controllers. However, as its name states, the second instrument combines both the deviation indicating and controller functions. The deviation indicating controller has a rotatable dial: when the variable matches the set-point the indicating pointer is either vertical or horizontal. Deviation indication is a valuable operator aid, allowing instantaneous perceptive scanning of the process measurements and noting of which variable is beginning to drift off control. Human engineering studies indicate faster operator response and interpretation to deviations from a horizontal, or 3 o'clock, reference. The two deviation instruments are available in pneumatic, but not yet in electronic, types.

Some types of recording controllers would be permitted on the control module. An example is the single-case, two-variable cascade recorder controller. It has not been practical so far for manufacturers to design and market a single-case, two-variable cascade indicating controller. Such other devices as annunciators and gages would be installed in the console top, the top section of the panel, or in a separate panel module.

30 points can be bought for $4,960 which for all intents equals the total differential of $4,950. However, under the column headed *5-ft wide module*, 32 points can be bought for $4790—a saving of $160 plus two spare recorder points. (This saving may not be considered significant, but the analysis does show how to approach an actual case.) If electronic instrumentation is to be used, then a module with three 12-point potentiometric recorders can also be considered, which would cost about $5,120 (not shown in table), or $170 per point for 30 usable points. Because of the greater cost, the potentiometric recorders could not be justified for the given example, if only economic reasons are considered.

MINIMIZE RECORDED VARIABLES

The preceding discussion is based on the fact that even with the conservative assumption of recording every controlled variable, it is sometimes possible to effect a saving by separating recording from control. A more realistic approach is to judiciously examine the need for permanently recording each variable (see box). Such an examination may permit a 50- to 70-percent reduction of recorded variables, and this can mean another significant saving. For instance, the table shows that 66 recorded points will cost $10,640, but reducing the number to 42 recorded points at $6,850 saves over $3,700.

The minimization of recorded points is based on recognizing that all process variables are not of the same magnitude of importance. All variables do not need permanently installed recorders and some variables never need be recorded. The logical approach is to analyze both the reasons for recording data and the functions of the control center. In particular, experience shows that the need for permanently installed recording points rarely exceeds 30 percent of the total variables measured during the startup period. After startup, many records no longer serve the operator any useful purpose and their presence on the control panel may be more of a distraction than a help.

The purposes of records

The recording function of instruments is entirely separate from the control function and should be evaluated as such. The reasons for recording key variables in any process are *accountability, heat and material balances, system analysis, performance,* and *trends.*

Accountability—The need for continuous information about inventory of materials or products and for billing of products bought and sold may require installation of permanent recorders.

Heat and material balances—Data about such key variables as flow rate, temperature, pressure, and density taken at the same time and for the same duration is often needed to determine plant performance and efficiency. However, a permanently installed continuous record of these variables is by no means mandatory since data in this category is intermittent in need and recording duration.

System analysis—The correlation of several variables to the same time datum furnishes information about process and equipment constants and characteristics and cause and effect of disturbances. Again, permanency of installed records is questionable. Once these data are taken, continuous recordings are

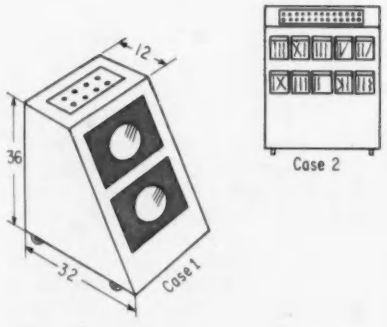


FIG. 2

FIG. 2. Three recorder module arrangements whose per point costs are detailed in the table: Case 1—Four-pen, 12-in. diam chart, pneumatic recorders; Case 2—Three-pen, miniature, pneumatic recorders; Case 3—12-point, 12-in. strip-chart potentiometer recorders.

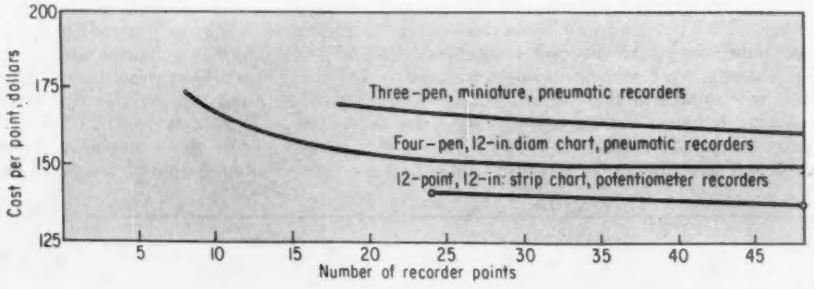


FIG. 3. Cost per recording point, for the three module arrangements in Figure 2, plotted from data in the table.

COST COMPARISON OF RECORDER MODULES

	2-ft wide module			3-ft wide module			4-ft wide module			5-ft wide module			6-ft wide module		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
Number of instruments	2	6	2	4	10	.....	6	14	4	8	18	.....	8	22	6
Number of pens	8	18	24	16	30	.....	24	42	48	32	54	.....	32	66	72
Estimated cost, $	1,380	3,060	3,400	2,520	4,960	.....	3,650	6,850	6,600	4,790	8,740	.....	.....	10,640	9,800
Estimated cost/pt, $	174	170	142	159	165	.....	152	163	137	150	162	.....	.....	162	136
Lease cost/pt/month, $	7.66	7.51	6.26	6.96	7.31	.....	6.71	7.21	6.11	6.61	7.11	.....	.....	7.11	6.01
Total weight, lbs	230	245	330	330	330	.....	410	410	540	520	520	.....	530	580	780

Case 1 Four-pen 12-in diam pneumatic recorders
Case 2 Three-pen, 4-in. strip-chart pneumatic recorders
Case 3 12-point, 12-in. strip-chart potentiometric recorders

not needed unless process conditions and equilibriums change significantly.

Performance—A performance record is often desirable for a particular operation or piece of equipment. At the outset of operation, it may not be too clear which variables give a good indication of performance, so that initially many records may be taken. With operating experience, that key variable —or perhaps two or three—which gives information about overall performance is recognized. Then the recording of extraneous measurements can be discontinued. As an example, consider a solids-gas reactor containing many temperature detectors. In a short time after startup, one or two temperature locations will be noted as giving the required information about performance and operating conditions, and these variables can be permanently connected to recorders. On the other hand, it is quite reasonable that a key performance variable—like product density —will be known and provision made at the outset for permanently recording it.

Trends—In processes with relatively large time constants, certain key variables allow detection of drift toward an undesirable situation. A permanent measurement and record of such variables allows the operator or controller to make corrective decisions.

Unfortunately, the decision to trend-record a particular variable is often arbitrary, with paradoxical results. For example, suppose a process variable with a 3-min time constant is traced on a miniature recorder whose pen motion is horizontal across a vertically moving strip chart. Depending on instrument elevation, the latest 5 to 7 min of recorded data on the platen top are invisible to the operator unless he purposely stands close to or above the instrument. Viewing the recorder from his normal sitting or standing position, the operator encounters a considerable delay in even seeing important trend information.

One valid process trend often overlooked in recommending variables for trend recording is the controller's output signal to the final control element. If a line is plugging due to fouling or crystallization, the controller senses small changes and continually sends corrective signals to the control valve. Thus, even though process conditions change, a trace of the controlled variable remains constant. There is no trend information until the valve reaches a limit, system drop takes over, and the controlled variable, now uncontrolled, starts to deviate. Trend information based on a record of the controlled variable may come too late. On the other hand, for the same situation, the output signal experiences an immediate continuous change.

Control center functions

A list of the major functions of the control center also serves as a guide for selecting those variables which are worthy of permanent recording. The following review may help establish a basic logic from which a definitive engineering approach may be formed for categorizing the many instrument and control devices found in the control center. The

How important is a permanent record?

The decision to record a variable has a material effect on the overall capital investment for instrumentation. One man should not assume the responsibility for making the decision, since he may take the safe position and recommend all variables for recording. Rather, the requirement is for a joint professional study of process recording needs by the instrument, process, and system engineers; by the project manager; and by the instrument maintenance foreman.

Concurrence to permanently record a variable can be reached by calculating a minimum weighted average factor. For instance, one method is to have each person assign point values from one to five to each variable proposed for recording in accordance with his estimate of its relative importance. An average of 3.8 or higher qualifies a variable for permanent recording.

major functions are *control, advice, information,* and *simulation and calibration.*

Control—The primary instrument function is control, the generation of signals to activate or position elements in control loops and prime energy sources for the process. Control signals may be originated by human operators and automatic controllers. Usually the control room is the center of origination. Output signals from control instruments, circuit actuation from switches, and output pressures from small pneumatic valves all leave this area.

Advice—The next function, in order of importance, is the receipt of advice. Here advice is construed as that essential information needed by the operator to assure best overall process performance and operation. The advisory categories consist of incoming continuous signals from field transmitters for key variables and parameters, incoming status signals, and approach-to-abnormal-condition signals.

Incoming continuous signals are used primarily for control. This category of advice signal is accepted by the controller which generates a correction signal. The outgoing correction signal is then in the *control* category mentioned above. A less important use of incoming signals is their display to the operator or supervisor. Should they be continuously recorded or is indication sufficient? The answer can be based on the reasons for recording listed previously.

Incoming status signals advise the process operator of the condition of equipment like pumps, fans, and agitators. Typical status signals are running lights, valve-position indicating lights, and lights indicating whether equipment like water treating units and filters are operating under *automatic* or under *manual* control.

Approach-to-abnormal-condition signals originate in the field from limit switches and safety devices and announce that variables are deviating from the desired normal values and approaching an unprofitable or dangerous condition. Annunciation is usually visual or audible. Recording annunciators store the sequence of the approach to abnormal and, usually by digital printout, identify the variable and indicate its magnitude and time of occurrence.

Information—Display of data of interest to the operator but not essential for process operation falls in the information category. An example is a panel-mounted pressure gage indicating main instrument air header pressure. The operator looks at this gage occasionally, but it is not under constant surveillance. By adding a pressure switch set at 20 percent below normal pressure, such information can be upgraded to the advice category. Then switch actuation (loss of air pressure) advises the operator the process is on the way to a shutdown.

Simulation and calibration—For extremely hazardous processes necessitating a remote control center, some provision should be considered for the remote calibration and simulation of key variables and instruments. One such process is a pressurized water nuclear reactor for generating steam. The reactor, shield tank, steam generator, and primary cooling system are all included in a large vapor container. The container withholds the pressure and vapor should any of these components rupture. The key instruments are inaccessible because of the radioactive environment. Provision must therefore be made to 1) impress (from the control center) known standard values of pressure, weight, and electrical parameters on the instruments in the vapor container to simulate probable process conditions and reactions and 2) observe the resulting output transmitted signals and the performance of the controllers.

CONSIDER RECORDER LEASING

The majority of record taking arises during the startup and shakedown periods of a process plant, involving the accumulation of data for system analysis, for trouble shooting, for time constant evaluation, and the like. Normally, the variables involved will be recorded for short times, and thus permanent recorders cannot be justified for them. This fact is already well recognized by both makers and users of instruments. Makers produce instruments with interchangeable (plug-in) recorder and indicator sections in the controller chassis. For the maker, this interchangeability feature meets customer's needs at an extra cost of about $10 per instrument case. For the user, interchangeability means that recorder controllers needed during startup can be easily converted to indicating controllers needed for normal operation.

Even with this arrangement, there is a large initial capital investment for equipment needed for short times. Following the concept described in Figure 1 of using only indicating controllers on the control panel and separate permanent recorders for key operating variables, it would appear logical to lease those recorders needed for short terms. Such an approach should be considered for new plants, for modernization programs, for changeover to new product production from existing facilities, and for pilot plants and semiworks.

While some makers offer instruments and data loggers on a rental or leasing basis, no one as yet leases the recorder modules described previously. Leasing of recorder modules will be an innovation in the instrument field, with opportunities for progressive companies to extend their business opportunities. Recorder leasing also appears to be a natural adjunct to the growing acceptance of contract maintenance from outside firms.

It will be interesting to see if the leasing concept is adopted and what lease rates are demanded. Estimated leasing costs on a per point per month basis are listed in the table, line 5, based on the total purchase cost in line 3 and on estimated fair returns on investment for an amortization period of two years. Such an amortization period appears reasonable since the average life of instruments is over 7 years, but no doubt the 2-year payout period will be challenged.

Short Guide to Military Synchro Specs

J. OPPENHEIM & B. SACHS, Ketay Dept., Norden Div., United Aircraft Corp.

Here are three tables designed to help the instrument engineer determine the military specification under which a particular synchro was built. While very few manufacturers mark synchros with specification numbers, nearly all date them with the month and year of manufacture. Other useful nameplate or decal data include: government agency (Navy, Army, or Dept. of Defense), size and type designations, null voltage readings, electrical error, and voltage ratings. This information, along with easily determined physical characteristics such as weight, length, and frame diameter, provide the clues necessary to pinpoint the applicable specs. Simple examples on the following page illustrate use of the tables.

TABLE 1—CHRONOLOGICAL DEVELOPMENT OF MILITARY SYNCHRO SPECS

Specification		(OS-671) MIL-S-2335	OS-3883	MIL-S-16892	FXS-1066 REV 4	MIL-S-17245	MIL-S-12472	MIL-S-20708	MIL-S-20708A
Issued by		BuOrd Navy	BuOrd Navy	BuOrd Navy	Army Ordnance (Frankford Arsenal)	BuOrd Navy	Army Ordnance	Department of Defense	Department of Defense
Issue date		(1949) 1950	1949	1951	1951	1952	1953	1958	1959
Frequency, cps		60	400	400	60/400	60	60	60/400	60/400
Sizes covered		1, 3, 5, 6, 7, 8	15, 18, 23, 31 no "a" suffix	11, 15, 18, 31 with "a" suffix Size 23 with or without "a" suffix	15, 23, 41 no "a" suffix	18 with "a" suffix	23, 31 with or without "a" suffix	All sizes general spec with "b" or "XN" suffix	All sizes general spec with "b" suffix
Static accuracy range, min of arc		18	10	6–12	6–8	8	6–8	6–8	5–8
Receiver error, min of arc		36–180	60	48–60	60	—	48–60	45	45
Control transformer null voltage range, mv	Total	40–60	60–75	60–75	60–75	75	60	40–60	40–60
	Fund.	(No test)	40	30–40	40	40	40	25–40	25–40
Remarks		←Vibration, shock, endurance→		←Vibration, shock, endurance, and humidity→				Vibration, shock endurance, humidity, and attitude −55 to +85 deg C Defines termina layout, circuit, and tests	Same as 20708, but with stricter test procedures
		−25 to +65 deg C Covers units designed 1939–1945	No temperature range mentioned	No damage at −54 to +77 deg C	−55 to +75 deg C all tests	No damage at −54 to +77 deg C	No damage at −80 to +160 deg C		

TABLE II
OLD AND NEW TYPE DESIGNATIONS

Type of Unit	Designation	
	MIL-S-2335 (OS-671)	Starting with OS-3883
Control transmitter	G	CX
Torque transmitter	G	TX
Receiver	F	TR
Control differential transmitter	DG	CDX
Torque differential transmitter	DG	CTX
Differential receiver	D	TDR
Control transformer	CT	CT
Bearing-mounted stator	B (suffix)	B (suffix)
High speed	H (prefix)	——
60 cycle	——	6
400 cycle	——	4

TABLE III
OLD AND NEW SIZE DESIGNATIONS

Part A. Sizes covered by MIL-S-2335

Size	Weight, lb (Approx.)	Length, in.	Diameter, in.
1	1½ to 2	3.9 to 4.2	2.25
3	2 to 3	5.2 to 5.51	3.10
5	5	6.0 to 6.8	3.39 to 3.63
6	8	6.4 to 7.5	4.5
7	18	8.9 to 9.2	5.75
8	60	13.13	8.63

Part B. Sizes covered by MIL-S-20708A

Size	Weight	Length, in. (w/o shaft)	Diameter, in.
08		1.240	0.750
11		1.732 to 1.789	1.062
12		2.692	1.125
15	Not	1.772 to 2.253	1.437
16	defined	2.593	1.537
18	by	2.520 to 2.670	1.750
19	spec	3.300	1.900
23		3.530 to 3.830	2.250
31		5.100 to 5.355	3.100
37		5.250 to 5.950	3.625

How the Tables Pinpoint Specs

Example 1. Suppose the decal reads "U. S. Navy, BuOrd, 15CT4". This indicates a Size 15, 400-cycle synchro. The "CT" provides no clue; this has always been used to designate a control transformer (Table II). The real clue is lack of an "a" suffix. Table I shows that the only Navy specification covering such a unit is OS-3883.

Example 2. Suppose the decal contains the designation "18CT6a". In this case, no further information would be needed; MIL-S-17245 is the only specification covering 60-cycle synchros in this particular size.

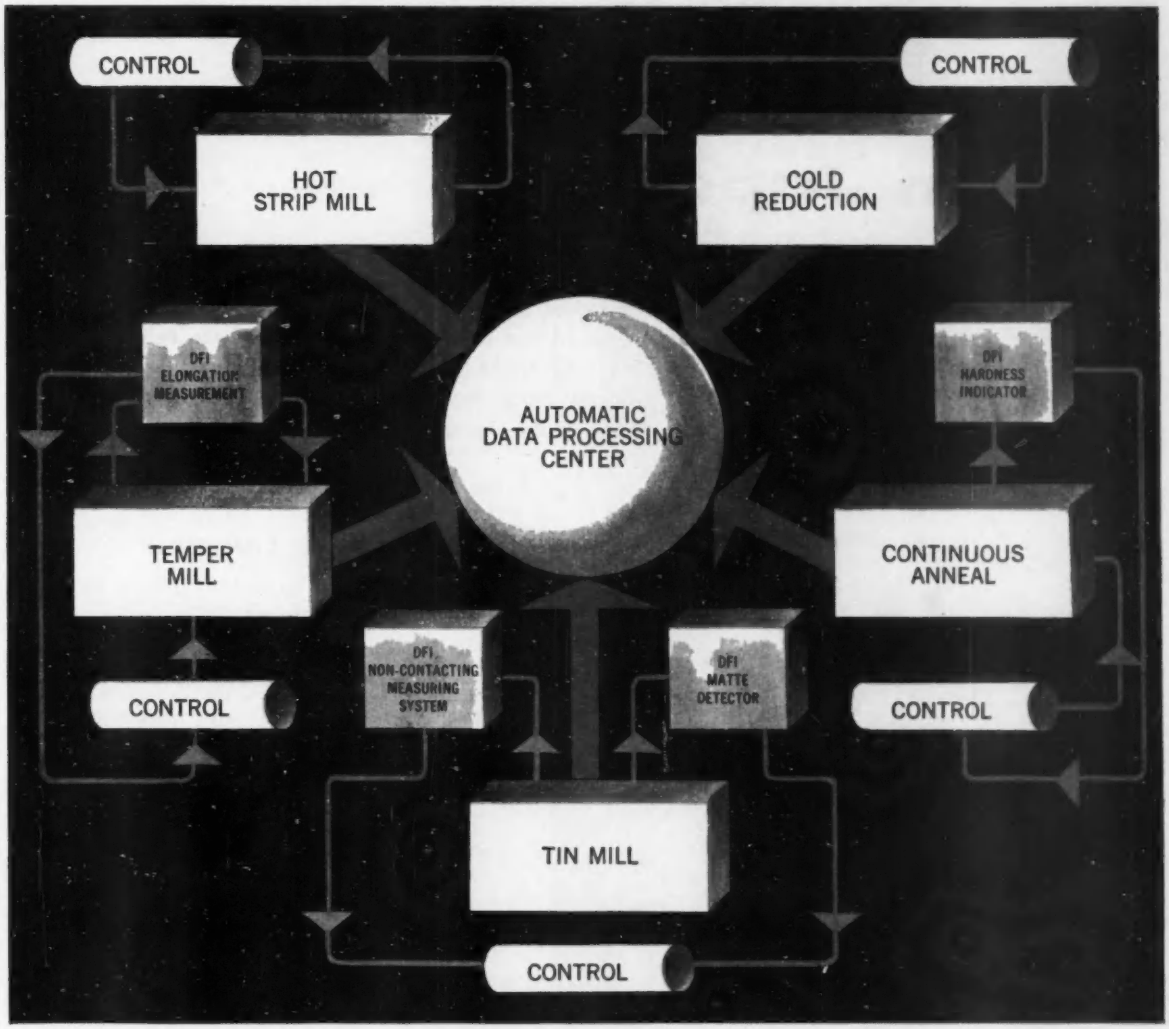
Example 3. As a final illustration, suppose the decal reads "23TR4b". Obviously, this is a Size 23, 400-cycle receiver and the "b" suffix indicates that MIL-S-20708 is the general specification for qualification tests and test procedures. Limiting values for performance testing of specific unit types will be found in supplementary sheets indicated by a number after the general specification, e.g., MIL-S-20708/50.

Some explanatory notes

The suffix "a", referred to in Table I has several meanings. In the designation of Size 15 and 18 400-cycle synchros, an "a" suffix denotes a 0.187-in. shaft diameter; earlier types with no "a" suffix had a 0.125-in. shaft diameter. On Size 15 and 18 60-cycle synchros, an "a" suffix denotes electrical changes rather than a shaft size change; by the time 60-cycle synchros were developed in these sizes, the 0.187-in. splined shaft had become standard.

Size 23 synchros (60- or 400-cycle) with an "a" suffix have 0.240-in. splined shafts; their non-"a" counterparts are electrically identical but have 0.240-in. threaded shafts.

An "a" suffix on Sizes 31 400-cycle units again denotes an electrical change; with or without the suffix, these have 0.250-in. splined shafts. Size 31 60-cycle synchros have 0.240-in splined shafts and no "a" suffix. A Size 31 400-cycle unit with a "c" suffix is electrically identical to an "a" suffix unit but, like the 60-cycle type, has a 0.240-in. splined shaft. Size 31 synchros with an "XN" suffix have the 0.240-in. splined shaft and also differ electrically. A "b" suffix generally denotes conformance to MIL-S-20708.



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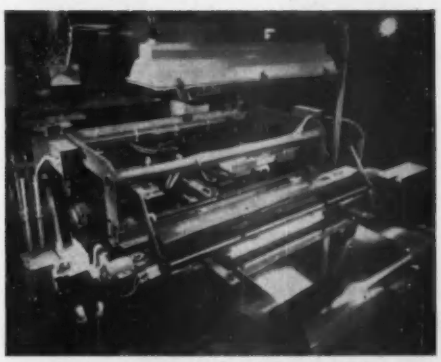

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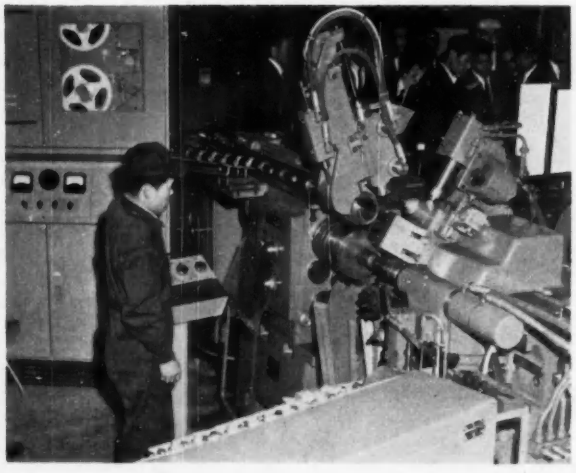
Numerical Control In Japan

Acting on a hunch that the industrious Japanese were busy in numerical control, CONTROL ENGINEERING editors asked two friends in Tokyo to scan the field. The friends, John Yamaguchi of McGraw-Hill World News and Kazuto Togino of the Government Mechanical Lab., promptly did so and uncovered details on five systems. Herewith is a picture-caption review of the Japanese innovations in numerical control.



1. FUJI PATH CONTROL . . .

which has been applied to a lathe for mass production of auto parts.

Fig. 1. One of several applications of the continuous path control system made by Fuji Tsushinki Mfg. Co. is this automatic lathe. Input medium to the incremental pulse handling circuitry, which was described in the November 1959 issue of CONTROL ENGINEERING, is ½-in. magnetic tape. A pulse distributor or director separate from the main control system handles the preparation of the tape. Tape pulses, each of which represents a discrete increment of movement, are fed to a forward-backward counter. Feedback pulses from the tool slides act to cancel the accumulating command pulses by driving the counter back to zero. A servovalve, actuated by width modulated square waves from the counter, controls the hydraulic drives on the machine.

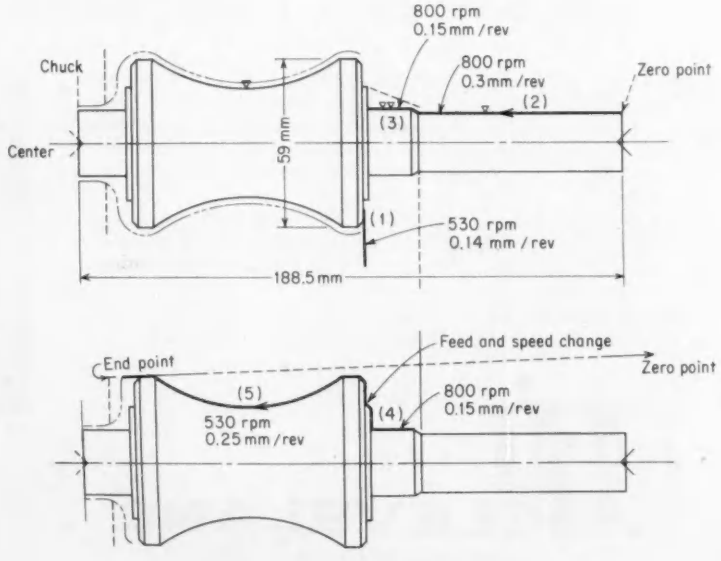


Fig. 2. Cutting diagram shows the operations performed by the lathe on the blank for a steering gear worm. Parts are moved through the machine by a completely automatic materials handling arrangement. Extensive sequencing control is required to synchronize auxiliary machine operations such as conveyor indexing, opening and closing the chuck, raising and lowering the exit hopper, and cycling the numerical controls.

2. RECORD-PLAYBACK SYSTEM . . .

a hybrid punched tape—magnetic tape control in which, oddly enough, the machine tool itself is made to serve as the director.

Fig. 3. This vertical turret lathe is the first application of the record-playback numerical control system developed by engineers of Shibaura Electric Co. Ltd., Tokyo. The system actually includes two separate sections: a six-channel punched tape positioning control and magnetic tape record-playback apparatus. The commands for cutting the first part of a lot are programmed onto punched tape. Then, while this part is being machined under punched tape control, all machine operations are simultaneously recorded on magnetic tape. The operator can make adjustments for cutter offset, tool deflection, machine inaccuracies, etc. while the recording is going on. This unique approach makes it possible to do without the data processors and directors normally associated with path control. The concept has proven adequate for the vertical turret lathe because 90 percent of the cuts it makes are straight line.

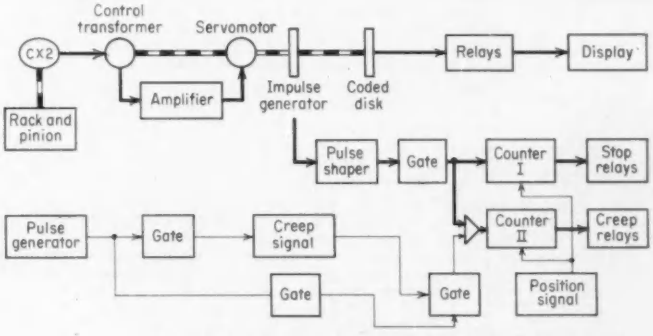


Fig. 4. The punched tape control is digital in nature and employs electronic ring counters as error registers. This block diagram for one axis shows the pulse generator that supplies presetting pulses to the counters. Each command block on the tape contains two coded numbers, one pertaining to the total machine movement desired and the other to the point at which the drive is to switch to creep speed for final approach. When these numbers are read into the system, counter I is preset with a number of pulses that is equivalent to the difference between the total counter capacity and the distance desired. Similarly, counter II is preset with a number that is the difference between counter capacity and the sum of creep distance plus total distance. Feedback pulses from the machine slide drive both counters forward. When counter I overflows, the creep relay switches the drive to slow speed.

Fig. 5. Feedback transducer for punched tape control consists of two synchros, servomotor, and amplifier packaged as shown. Objective of this design is to minimize load on precision rack mounted on machine slide. Pinion drives only the control transmitter, which is coupled electrically to the synchro transformer and servomotor in a conventional closed loop (see Figure 4). Servomotor drives the impulse generator for feedback and the coded disc which supplies continuous information to the Nixietube position indicator on the control panel.

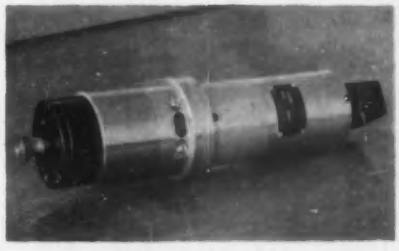
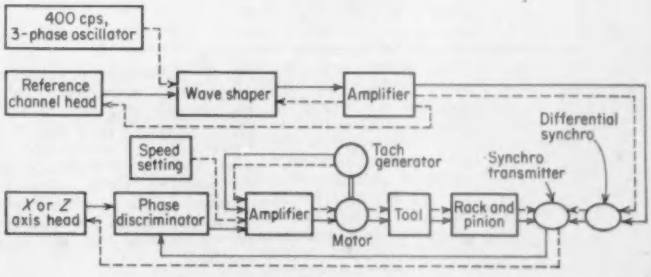


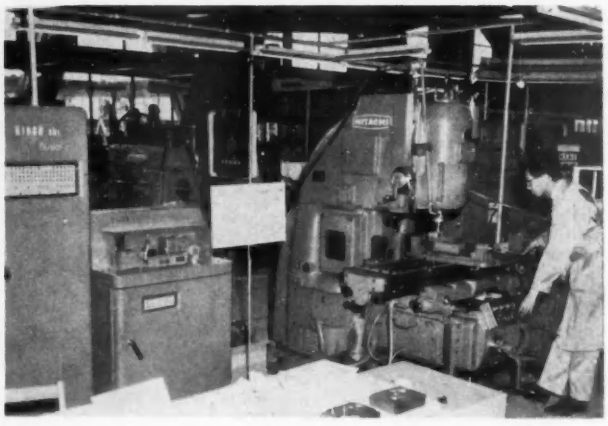
Fig. 6. Magnetic tape record-playback control is completely separate from positioning system. Dotted lines identify the record mode and solid lines the playback mode. For record the output signal of the synchro transmitter is fed directly to the command track head. The three-phase oscillator output is recorded simultaneously on the reference channel. In playback the reference track is used to excite the transmitter stator, while the signal on the command track is compared with the transmitter feedback signal in the phase discriminator. The latter delivers a dc voltage proportion to the phase error that is amplified and used to power the dc drive motor. The operator can modify the original program to compensate for cutter offset and wear by means of the synchro differential. The system also can record voice instructions and auxiliary commands.



3. HIDAM 401 PATH CONTROL . . .

in which the director is an integral part of the machine control unit.

Fig. 7. This is one of two continuous contouring controls manufactured by Hitachi Ltd. of Tokyo. The unique feature of this system is its use of two separate servo-loops per axis, one on the machine tool and the second within the director. The control medium is six-channel punched tape which enters the system by means of a mechanical tape reader. The large cabinet at the left contains a clock generator and large scale transistor multivibrator circuitry. This pulse distributor uses the numbers on the input tape to set multivibrator gates in the output line of the clock generator. The gates allow pulses (each of which represents a discrete increment of distance) to pass into a digital servo in sufficient quantity to produce the movement required by the number coded on the tape.



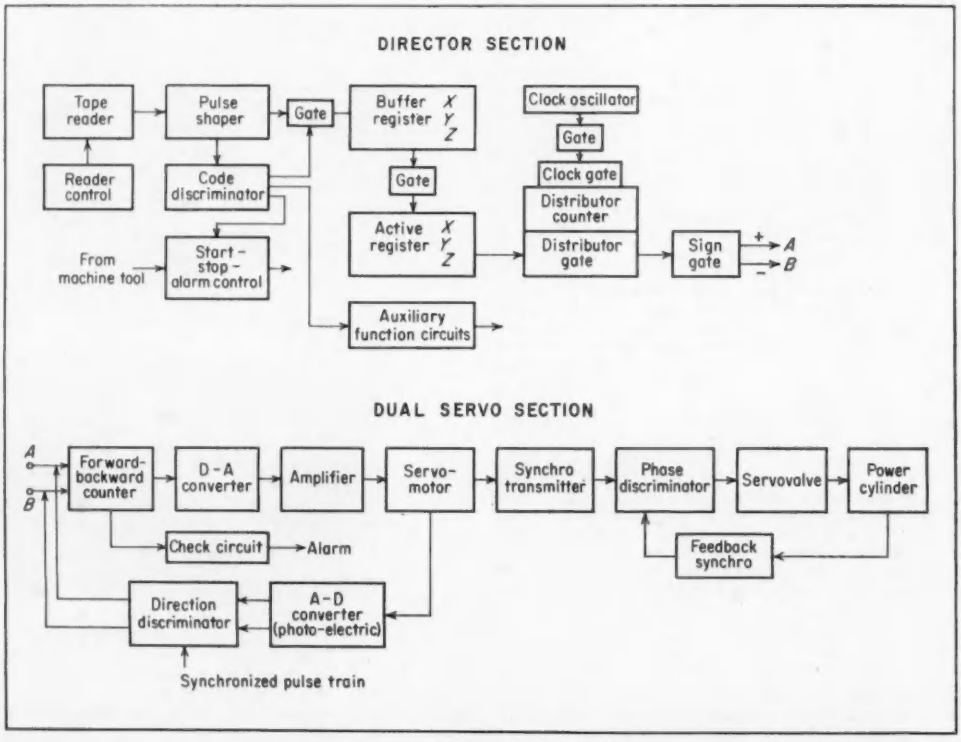


Fig. 8. Schematic of director and machine control loops shows "piggyback" arrangement of servos. The director does not control the machine tool directly, but gates command pulses into a digital servo located within the director cabinet. This loop controls the movement of a servomotor which has a synchro transmitter for a load. The digital feedback device geared to this servomotor is a photoelectric pulse generator that feeds a forward-backward counter. As the synchro transmitter is moved by the digital servo, its output signals are used as the input to a second hydraulic servo on the machine tool. This is an analog system using a synchro for feedback.

4. HIDAM 402 PATH CONTROL . . .

for which control tapes are prepared by means of a director separate from the machine tool.

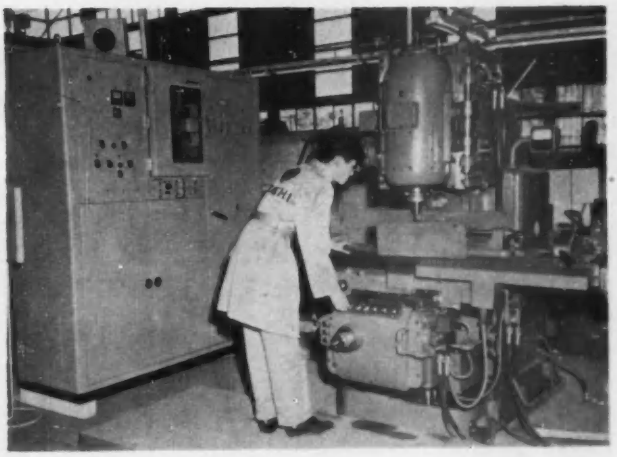


Fig. 9. The Hidam 402 is similar in concept to the General Electric system in the U. S. Shown here are a vertical milling machine and the associated control unit. Magnetic tape, which is prepared in a separate director, contains the command signals for the three axes of motion. The signals are in the form of phase modulated synchro voltages which are compared with the feedback voltages from the synchros geared to the machine slides. The speed of the machine drives is a function of the amount of phase shift of the recorded signals and hence is not limited by the packing density of the magnetic tape. Hitachi Ltd. builds machine and control.

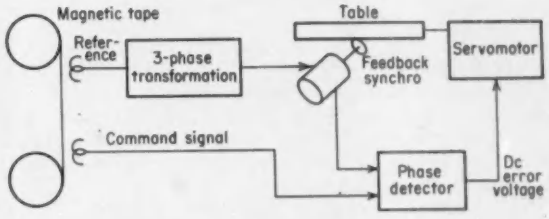


Fig. 10. This is a simplified diagram of the machine control. One track of the tape carries a 400-cycle reference sine wave voltage that is converted into three phase and used to excite the stator of the feedback synchro. The phase detector compares the output of the synchro rotor with the signal recorded on the motion channel of the tape. If these signals are in synchronism, the output of the detector is zero. If there is a phase difference, however, the resulting error signal energizes the servomotor, and the table moves appropriately.

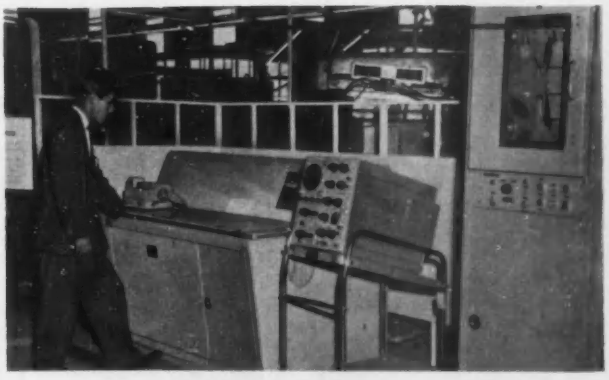


Fig. 11. Director is completely transistorized. Photoelectric tape reader, at the left of the console desk, reads six- or eight-channel punched tape at rate of 200 lines per sec. The function of the director is to convert punched tape data on the machine movements desired, as prepared previously by the parts programmer and a general purpose digital computer, into analagous synchro voltages. The director converts the numbers on the input tape into pulse trains, which are then used to phase modulate the output of a 400-cycle oscillator. The tape recorder at the right records the oscillator signals.

5. JIG BORER POSITIONING SYSTEM . . .

which uses not one, but two tape readers.

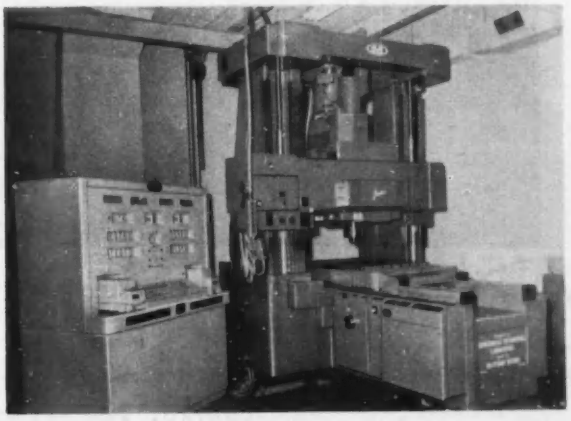


Fig. 12. The Japanese Government Mechanical Lab. has recently completed construction of the machine tool and control shown here. The control is substantially the same as the prototype, first described in CONTROL ENGINEERING, February '58. An outstanding feature is the optical position measuring system. Coarse positioning is accomplished by counting marks that are spaced 1 mm apart along the main scale. The fine-positioning transducer consists of two glass plates or diffraction gratings inscribed with fine parallel lines. One slide is fixed to the machine slide, and the other is stationary. The gratings block out a beam of light passing through once for each micron of movement. Thus the system can interpolate between the main scale markings by counting the interference pattern. The two tape readers can be seen at the right and left of the control cabinet. Both operate simultaneously, one providing position information and the second, sequencing instructions.

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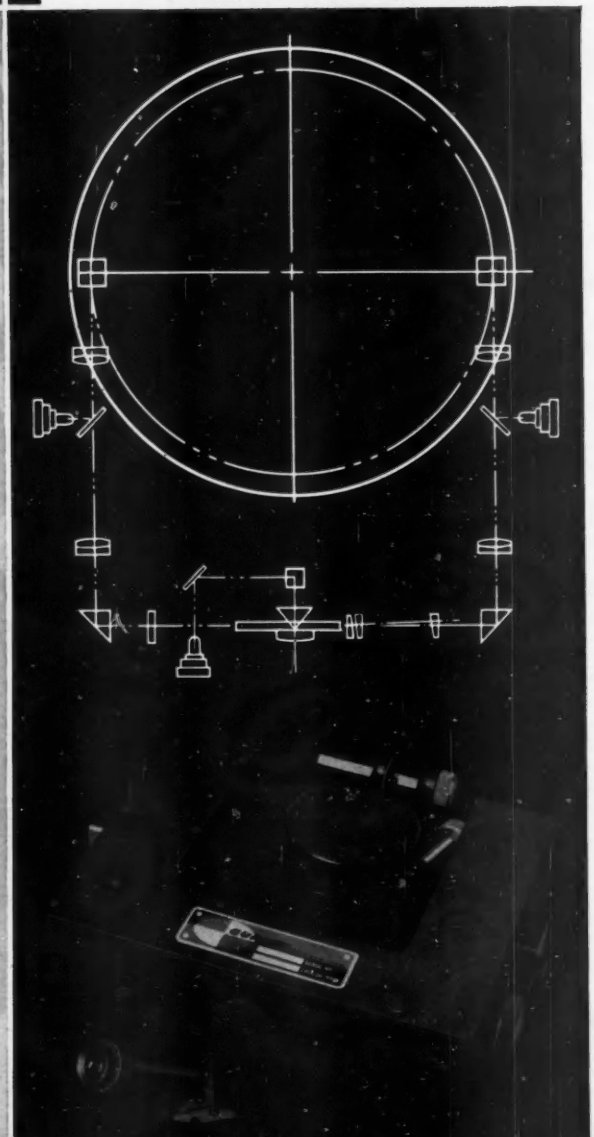

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Flux Gate Head Reads Stationary Magnetic Tape, DC Signals

DAVID KERR, Ultra Electric Ltd., England

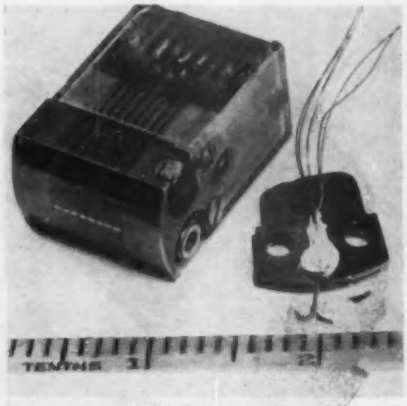

FIG. 1. An eight-channel flux gate head. Single head at right shows gold-plated Permalloy tapes before they are clamped by brass head assembly and ground off flush with surface.

Preparation of punched paper tape for teletype transmission direct from a computer is slow—normal perforators operate at maximum speeds of about 33 characters per sec. High speed punches increase the rate to around 300 characters per sec but these are intricate and expensive, and even then the information output rate is far below the computer's operating speed. An alternative solution better utilizes the computer's speed by recording the output on magnetic tape, but this requires an intermediate information handling step to convert magnetic tape to punched tape for the slow speed teleprinter transmission.

A recently developed flux gate reading head eliminates both these difficulties by reading information directly from stationary magnetic tape. The computer output is recorded directly on magnetic tape at high speed. The magnetic tape is transferred to the static reader, which inches the tape character by character to produce an electrical signal directly coded for transmission over teletype lines. Inching speed is determined by tape packing density and line transmission characteristics. Normal maximum transmission speed is 6 characters/sec. With a tape packing density of 100 characters/in., inching speeds are as low as 0.06 in./sec.

The flux gate head in the stationary reader is made from 0.5-in. lengths of 0.002 in. thick Permalloy magnetic strip with a centrally punched hole. Four-turn excitation coils are wound on each side of the hole and connected in series opposition to a 50-kcps energizing supply. A seven-turn read coil is overwound around the complete strip. The reading head (Figure 1) is produced by bending the strip into a loop with the strip ends embedded in the brass head assembly. Gold plating of the ends provides magnetic insulation in the 0.002-in. gap.

The excitation from the series opposed coils saturates the strip in both directions at twice the energizing frequency. This flux change produces no output in the read winding because the exciting windings are balanced. Static tape reading is done by positioning the coded tape across the gap in the reading head magnetic circuit. Recorded flux from the tape biases the cyclic saturation of the core material and induces a phase modulated output signal in the read winding of about 1 mv amplitude.

Figure 2 shows the system developed for direct five-digit teletype code output from a magnetic tape input. Five heads on a six-head reading assembly detect the five tape information tracks, character by character. The phase modulated outputs after amplification are detected in 100-kcps transistor demodulators. The five-wire output can be fed into a serializer and then directly into a telegraph line or teleprinter. Alternatively, the outputs can be used to operate an electric typewriter via a suitable decoder or directly into a paper tape punch.

The tape drive motor is nominally set for the maximum possible transmission rate and is synchronized from a clock pulse track read by the sixth head. The clock pulse indicates the presence of an information block on the other five channels and operates a flip-flop to switch off the drive motor during the reading operation. Completion of the readout is indicated by a clearing pulse from the coder which restores the motor drive to advance the tape for the next character. For large gaps between information blocks, an automatic speed-up switches in a fast drive until the first character of the next block is received.

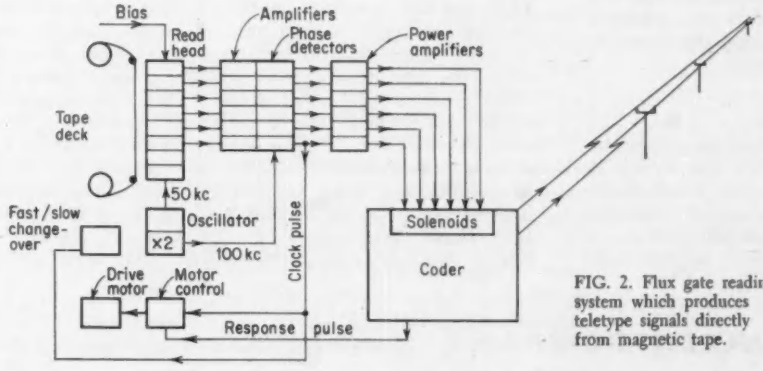

FIG. 2. Flux gate reading system which produces teletype signals directly from magnetic tape.

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Separate Signal from Noise with Probability Filters

THE GIST: The success of a control system often hinges on the ability of its designer to make it perform in a noisy signal environment. When the signal cannot be made larger without also amplifying noise, the answer is to filter the noise. But noise usually has many components at signal frequencies, so ordinary frequency dependent filters won't work. The statistical properties of noise, however, are very often unrelated to those of the signal even when they occupy the same frequency band. Therefore there is a way of recognizing noise and rejecting a large part of it. The author discusses certain statistical relationships which are often useful in recognizing and filtering noise and then develops a probability filter that is simple to instrument and remarkably effective. A computer simulation shows a 300 percent improvement in effectiveness for a heavily jammed guided missile system.

WILLIAM L. STILL
U.S. Air Force, Gardena, Calif.

It is possible to separate signal and noise only insofar as tests for their differing characteristics can be defined and instrumented. It is axiomatic that no further separation is possible until additional distinguishing features can be measured.

Linear control theory provides tools for testing the input signal on the basis of its power frequency spectrum. It assumes that while neither the exact message nor exact noise signals can be predicted, it is possible to analyze typical data and define the most probable power distribution across the frequency spectrum. The frequency response of the control system can then be tailored to match, and its output will contain a compromise representation of the maximum frequency spectrum of the signal and the minimum spectrum of noise. Many sophisticated and powerful techniques exist in this area.

Since two points in time are necessary to determine any individual sinusoid within a frequency spectrum, an infinite number of points are necessary to determine the spectrum itself. The tailored linear control system just described, inherently operating on a time lag, thus may be said to continuously measure all the intervals between zero and infinite time lags, selectively weighing them to accept valid signals and reject noise on the basis of the most probable power frequency spectrum of each.

Statistical properties of signals have been used very little so far, but certain of them offer additional signal improvements when used in conjunction with response shaping techniques.

Autocorrelation techniques

In linear systems the best statistical measure is the correlation function, generally defined as:

$$\phi_{ab}(\tau) = \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} [f_a(t)]\,[f_b(t+\tau)]\,dt \qquad (1)$$

Where, if $a \neq b$, ϕ_{ab} is the cross correlation function.
if $a = b$, ϕ_{ab} is the autocorrelation function between $f_a(t)$ and $f_b(t)$.
$f_a(t)$ and $f_b(t)$ are stationary random processes

Normally the signal and noise are uncorrelated, so only the autocorrelation function need be discussed. This is a phase-destroying but frequency-preserving transformation. Considered in the time domain the correlation function gives a statistical estimate of how well the future value of a signal can be extrapolated from measurements made on its past. When converted into the frequency domain it measures the rms power existing throughout the spectrum.

An alternate, and less frequently used, definition of the autocorrelation function is:

$$\phi_{11}(\tau) = \int_{\infty} \int x_1 x_2\, p_\tau(x_1, x_2)\,dx_1\,dx_2 \qquad (2)$$

where $x_1 = f_1(t)$
$x_2 = f_1(t+\tau)$
$p_\tau(x_1, x_2)$ = the probability that the values of x_1 and x_2 will exist, separated in time by exactly τ seconds.

This definition is operationally cumbersome. Its chief value is that it expresses the correlation func-

tion in statistical terms. It is the second probability distribution of the random process.

Equation 2 again shows the dependency of the linear system on a time lag. A system designed on the basis of the correlation function will respond to an actual signal as if that input were going to correlate with a future value defined by this second probability distribution. The disadvantage of this approach is that while the correlation function preserves frequency and amplitude, it destroys phase information. In the time domain this is analogous to assuming that all amplitudes can be represented by their rms values.

But there are many inputs where rms values do not give a good representation of the data—large variations from rms can occur and thereby introduce appreciable errors. Impulse-type noise can be used as an example. A single random pulse contains a large number of sinusoidal frequencies of low individual rms values. The pulse occurs when these frequencies come into phase simultaneously. When a linear system sees such an impulse it must accept it as a true rms value and attempt to respond on this basis. The result is a large overshoot on an input of low probability. A test is needed to determine and compensate for those cases where phase data causes deviations from rms values.

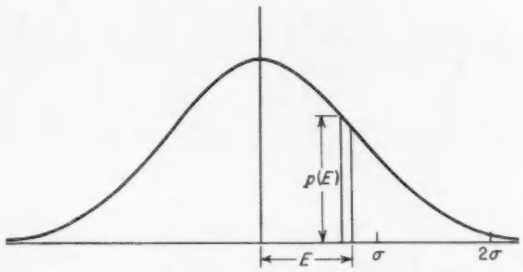

FIG. 1. A typical first probability distribution.

Dynamically variable filters

The first probability distribution provides such a test. This distribution defines the probability that the signal will have a specified amplitude at any instant in time. Since it samples only one point in time, it is independent of the frequency spectrum. Thus it defines only amplitudes which will probably be produced by phase variations within the spectrum.

Figure 1 shows a typical first probability distribution where the ordinate at E represents $p(E)$, the probability of that value of E occurring. This probability distribution can be instrumented to supplement linear systems through Equation 3.

$$\bar{E} = \int E\, p(E)\, dE \qquad (3)$$

E = the error signal
$\bar{E}$ = average value of error
$p(E)$ = probability of such an error existing.

The portion of Equation 3 under the integral sign is diagrammed in Figure 2 with an illustrative error signal. The error signal input is represented on the y axis reflecting its output onto the x axis as shown. The shaded area of the input signal is never seen by the control system. The probability of it being a true error signal and not noise is so small that it receives only a small weighting in the nonlinear function generator.

The complete implementation of Equation 3 is shown in Figure 3. The output of the error weighting function is integrated and fed back to be subtracted from the input. For the feedback loop to drive the error signal to zero, it must sum the output of the function generator through all intermediate incremental values of $E\, p(E)$. This must be independent of the time duration of the error itself, thereby completing the integral of Equation 3. The system acts only on the best estimate or average value of the true error signal.

If the probability distribution is Gaussian, the weighting function shown in Figure 2 will exhibit

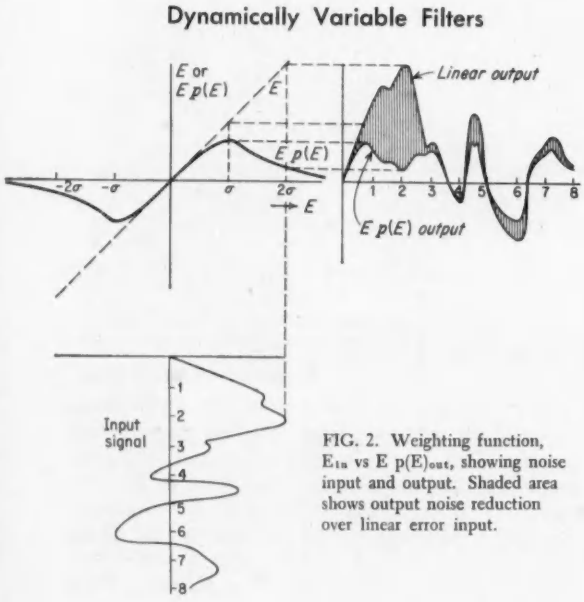

FIG. 2. Weighting function, E_{in} vs $E\ p(E)_{out}$, showing noise input and output. Shaded area shows output noise reduction over linear error input.

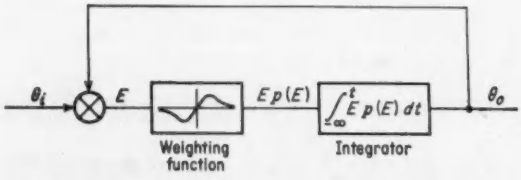

FIG. 3. Closed-loop representation of a simple probability filter.

maximums and minimums at the positive and negative rms values of the signal. Error signals smaller than rms will pass through the weighting device with little or no distortion, and the system will behave as though it were linear. These values contribute to the spectrum power because of their high probability of occurrence rather than their amplitude. The reverse is true for values larger than rms. Their probability of occurrence is small, but their high amplitudes would contribute markedly to the power within the spectrum.

It was stated earlier that a linear system must operate on a time lag between output and input. The input thus establishes the pattern which the output attempts to follow. When the nonlinear probability filter is used in conjunction with the linear system as shown in Figure 3, it operates on the error which exists during the time increment of the linear lag. It thereby tests the incoming signal with the output as a reference. It uses as a test criteria the probability that the new signal will deviate by the amount of the error signal from that already accepted as valid at the output. This is shown by the closed-loop transfer function (of Figure 3):

$$\theta_o(s) = \frac{\theta_i(s)}{\frac{s}{p(E)} + 1} \tag{4}$$

The time domain impulse response is:

$$\theta_o(t) = \theta_i(t)\, p(E)\, e^{-p(E)\, t} \tag{5}$$

Since $E = (\theta_i - \theta_o)$, it can be seen that the input affects the output only to the extent that the change in signal is probable within the response time of the filter. The time constant itself is $1/p(E)$ seconds. An error of low probability will narrow the filter's bandwidth in a manner proportional to $p\ (E)$. Therefore the error must exist for a time longer than $1/p(E)$ before the output is appreciably changed. As this change occurs, $p\ (E)$ will increase as the error decreases, the bandwidth will widen because of the higher probability, and the speed of response will increase.

A step function with an amplitude probability less than one standard deviation would be accepted and passed through as though the system were linear. If the amplitude were 2σ, or greater, the system would see only a very small error because of the low probability. It would respond very slowly at first, but the fact that the signal persisted would gradually reduce the error. The smaller error would indicate an increase in probable validity and thereby accelerate the speed of response. As the error was reduced to below the 1σ level, the response would again approach linear behavior.

Figure 4 shows three representative responses to step inputs of differing probabilities for both a linear system and the same system with probability filtering added. It shows the characteristics of fixed rise time with an overshoot proportional to the step amplitude

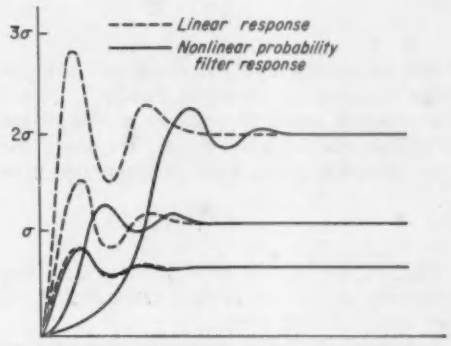

FIG. 4. Step function responses for linear and E p(E) filters. Lag of linear filter is constant; overshoot is direct function of error amplitude. Lag of probability filter is function of error amplitude; overshoot is constant.

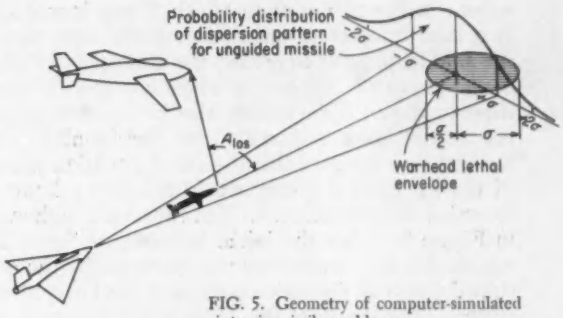

FIG. 5. Geometry of computer-simulated air-to-air missile problem.

for the linear system. The nonlinear filter shows the characteristics of a relatively fixed overshoot and a rise time as a function of the probability of the input amplitude.

By use of information theory techniques it is possible to derive the proper equation to be instrumented in the weighting function shown in Figure 2:

$$E\, p(E) = \frac{E\, p(\Delta\theta_i)}{p(\Delta\theta_i) + p(n)} \tag{6}$$

$E\, p(E)$ = weighting function to be instrumented
E = linear error signal
$p(\Delta\theta_i)$ = probability that the input θ_i will change by the amount θ_i within the inherent time lag of the linear portion of the system
$p(n)$ = probability that error signal seen is due to noise superimposed on the input.

In general $p(n)$ will be much greater than $p(\Delta\,\theta_i)$. The system is designed to have θ_o follow θ_i as closely as possible, and it is usually safe to assume that major perturbations are due to noise rather than signal changes. Equation 6 will then reduce to the general shape of the curve shown in Figure 2.

Simulation proves probability filters effective

An analog computer study was run to illustrate the effectiveness of probability filtering in the presence of heavy Gaussian noise jamming. The simula-

tion assumed a highly idealized air-to-air guided missile problem, as shown in Figure 5. The problem assumed a constant velocity missile flying a pure collision course, a simple case for which the control equation for the missile guidance system would be

$$\frac{d(A_{los})}{dt} = 0 \qquad (7)$$

That is, the missile must hold to zero the angular velocity of the line of sight from itself to the target in order to score a hit.

A first set of 100 computer runs were made as a control, or standard of comparison, in which the simulated missile was fired ballistically without guidance. A missile fired without guidance as a purely ballistic rocket would have a finite probability of kill p_k due to the initial accuracy of the fire control system in the fighter from which it was launched. If a large number of unguided missiles were fired, it would be possible to predict the dispersion pattern of the group but not exactly where any specific missile would go. This pattern should be centered at the impact point required to kill the bomber. It was therefore assumed that the initial condition errors of the fire control system would fall into a known Gaussian distribution centered at the target, as shown in Figure 5. Thus the initial launch error for each run in this first control set was governed by the assumed Gaussian dispersion pattern of the fire control system. The results of this control set are plotted in Figure 6 as the number of missiles passing the target with any given miss distance (in standard deviations σ).

The second set of computer runs simulated linear guidance with heavy Gaussian noise jamming, starting with the same Gaussian distribution of initial launch errors. For this and all subsequent runs the computer was calibrated in terms of standard deviations of the initial launch error for easy comparison with the control set. The results of this set of runs is plotted as Figure 7A and shows by comparison with Figure 6 that the jamming is heavy enough to neutralize the effects of the guidance system.

For each of these tests the probability of kill was calculated as the ratio of the number of missiles which passed within the lethal envelope of the warhead to the total number fired. It was previously assumed that the missile had a blast-type warhead and a proximity fuse, that the probability of kill would be unity if the missile passed through the lethal area from 1σ in front of to $\frac{1}{2}\sigma$ behind the target, and that outside this area p_k is zero.

In the third test set of runs, a probability filter was used to reduce the effects of jamming by instrumenting the Gaussian initial launch error distribution in the linear guidance system. To accomplish this, each new value of the guidance error signal was tested against a criterion represented by the probability of the fighter's fire control system ever allowing so large an initial error to occur. The non-

Computer Tests Probability Filters

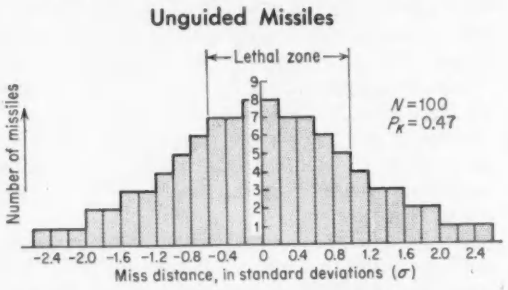

FIG. 6. Dispersion pattern due to initial launching error for unguided (ballistic) missile was assumed Gaussian. Simulation results were plotted as number of missiles at various miss distances normalized in terms of the standard deviation σ.

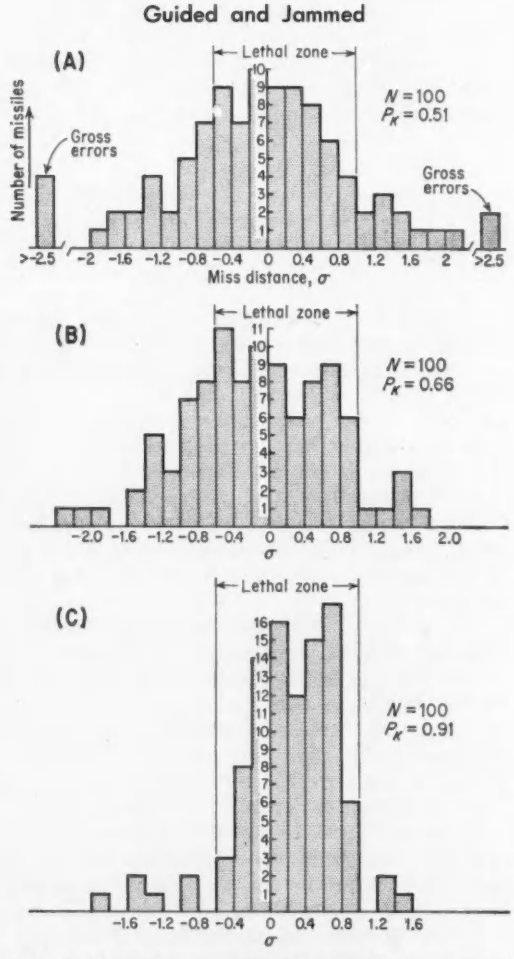

FIG. 7. Dispersion patterns for guided missiles in presence of heavy Gaussian noise jamming, A—linear guidance only. B—linear guidance plus probability filter to reduce effects of initial launching errors. C—linear guidance plus initial error filter plus lethal zone detection.

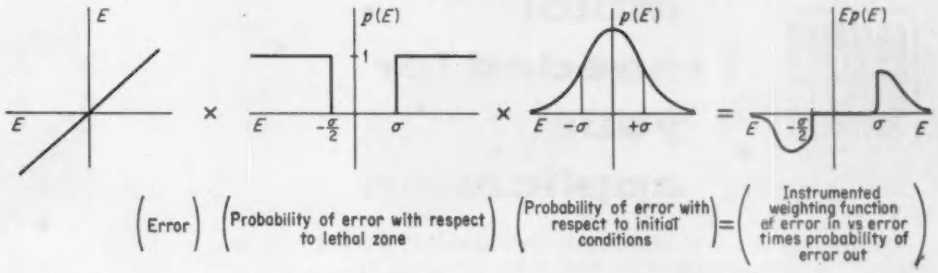

FIG. 8. Derivation of E p(E) weighting function for final simulation tests which produced 300 percent improvement in effectiveness of weapon system.

linear probability filter was set up on the computer's diode function generator as the same function shown in Figure 2. For a linear error input the output was $E\,p(E)$. The result of this test is plotted in Figure 7B. The probability of kill had improved from 0.5 to 0.65, or by 30 percent.

A final test set of 100 runs was made to illustrate that the pertinent feature of the problem was the intelligent definition of a valid signal rather than an absolute measure of error voltage. A new probability function was derived from the additional fact that the missile, to establish a kill, need only pass through the lethal envelope. Thus any error signal which indicates that the missile will pass through this area adds no new information. The desire is to kill the aircraft, not necessarily to hit it. This new weighting function as derived in Figure 8 does not do much to reduce any action the control system might take on a valid error signal, but it reduces even further those areas where noise can enter the system. The weighting action shown in Figure 9 illustrates the noise power reduction over a linear system subject to the same noise. The results of this final set of runs using the filter of Figure 8 are shown in Figure 7C. The proability of kill in the presence of heavy jamming has been increased from 0.5 to 0.91, an 80 percent improvement!

The significance of this increase is stressed by the fact that three missiles would have to be fired at a p_k of 0.5 to insure the same overall kill probability as a single missile fired at $p_k \doteq 0.91$. Thus, for this specific case, the 80 percent increase in p_k would result in a 300 percent overall increase in the efficiency of the weapons system.

Probability filtering can save weight and power . . .

As an additional benefit, probability filters free the designer from the usual requirements of specifying linearity in power servos. This can result in reduced component size and power rating, as well as reduced requirements from the source of control power. From another standpoint, nonlinearities such as saturation characteristics can even be exploited as a portion of the probability filter.

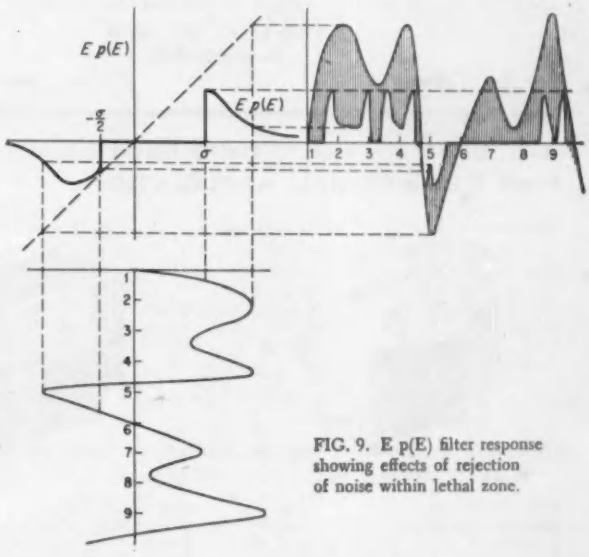

FIG. 9. E p(E) filter response showing effects of rejection of noise within lethal zone.

. . . may make present design criteria obsolete

We are now on the verge of a new era—space travel. It is easy to see that as one of the characteristics of this new age, space flights must involve the use of highly predictable trajectories for their vehicles. High fuel to payload ratios will impose weight penalties on the order of a thousand to one. It is quite possible that the difficulties to be surmounted may result in the specification of design criteria involving minimum adequacy of the subsystems, rather than the luxury of optimum performance. The only factor which can and must be truly maximized is the probability of mission accomplishment. The fields of linear programming and game theory are presently being exploited by operations analysts in similar problems. These, coupled with information theory, when properly adapted or exploited, may easily be the future tools of control systems engineering.

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Did you know that Barber-Colman Company makes both a-c and d-c motors? On these pages we have tried to tell very briefly a little about each of our motors. Featuring high quality at low cost, Barber-Colman 115 volt a-c (6-220 volt optional) shaded pole motors are excellent for commercial and industrial applications. Barber-Colman d-c precision motors are available in a variety of voltage ranges, styles and specifications to meet airborne and industrial applications. Look at the motors illustrated and then ask us for more literature on the one that interests you most.

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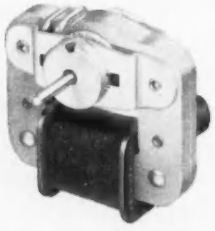
Booths 2242-44

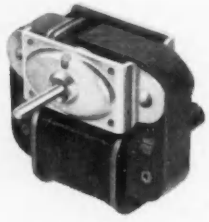
New York Coliseum **March 21-24, 1960**

A-C SHADED POLE UNIDIRECTIONAL MOTORS FOR COMMERCIAL APPLICATIONS



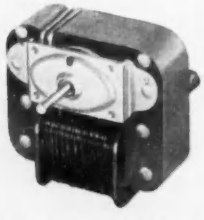
AYAA — DYAA — KYAA

Specifications:
Rated horsepower . . .0007 to .0010
Length . . . . . .1-1/8" plus shaft
Dimensions. . . . .2-7/32" x 2-1/4"
Remarks . . . .Exceptionally small and compact
Typical applications — fan blades, blowers, reroll chart drives, phonographs, and gear trains.



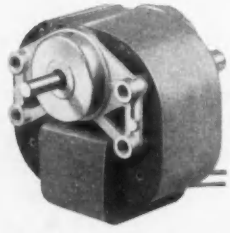
DYAB — KYAB

Specifications:
Rated horsepower . . .0017 to .0066
Length . . . .1-5/8" to 2" plus shaft
Dimensions. . . .2-3/8" x 2-19/32"
Remarks . . . .High starting torque
Typical applications — slide projector fans, hair dryers and refrigerators, vending machines, office machines, and rotisseries.



DYAF — KYAF — OYAF — CYAF

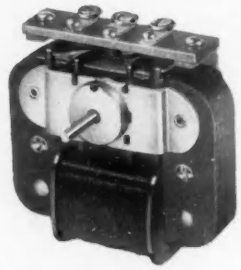
Specifications:
Rated horsepower . . . .0045 to .032
Length . . . . . .1-5/8" to 2-9/16" plus shaft
Dimensions. . . .2-21/32" x 2-3/4"
Remarks . . . .High running torque
Typical applications — fans for heaters, deodorizers and electronic equipment; blowers and gear trains.



AYAR — BYAR — CYAR — DYAR EYAR

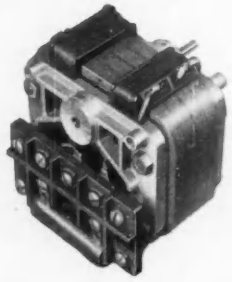
Specifications:
Rated horsepower . . . . .005 to .050
Length . . . . . .1-29/32" to 3-11/32" plus shaft
Dimensions. . . . . .3-1/8" x 3-1/4"
Remarks . . . . . .High start or high power rotors available
Typical applications — pumps, humidifiers, vaporizers, combustion and industrial controls.

A-C SHADED POLE REVERSIBLE MOTORS



AYAG — AYAE — BYAE

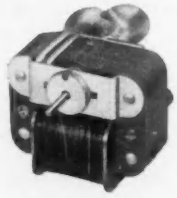
Specifications:
Rated horsepower . . . .00015 to .006
Length . . . . . .1-13/64" to 1-53/64" plus shaft
Dimensions . . . . . .3" x 2-7/8"
Remarks . Adaptable to 1 or 2-phase operation and electronic control
Typical applications — servomechanisms, remote switching and positioning devices, and pen drives.



CYAE

Specifications:
Rated horsepower . . . . . .0055 to .04
Length . . . . . .3-1/8" plus shaft
Dimensions . . . . . .3-7/8" x 3-7/8"
Remarks . Adaptable to 1 or 2-phase operation and electronic control
Typical applications—servomechanisms, recording instruments and automatic weighing machines.

A-C SHADED POLE SYNCHRONOUS MOTORS

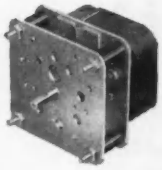


KYAJ — DYAJ

Specifications:
Rated horsepower . . . . .0043 to .0086
Length . .1-3/4" to 2-1/8" plus shaft
Dimensions . . .2-11/32" x 2-19/32" or 2-23/64" x 2-19/32"
Remarks . . .Develop 30 times power of ordinary clock motors
Typical applications—oscillographs, scoreboard timers, viscometers, facsimile recorders, x ray timers, and microfilm cameras.

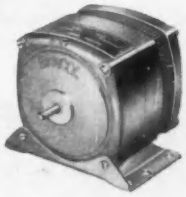
A-C GEARED MOTORS

SYNCHRONOUS UNIDIRECTIONAL
REVERSIBLE



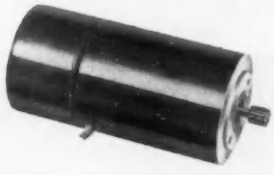
DOUBLE-PLATE

ENCLOSED TYPE



Barber-Colman a-c geared motors provide ratios from 4:1 to 1,333,800:1. Heavy duty gears and output shaft plus long life lubrication add to the reliability of these geared motors.

A-C 400-CYCLE MOTORS

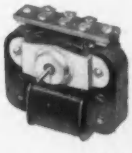


AYLO

Specifications:
Type . . Split-phase capacitor, squirrel cage rotor
Rated horsepower . . . up to 40 mhp intermittent duty
Voltage . . . . . 115 V a-c
Rated speed . . . . 9500 to 11,000 rpm
Length . . . 2.20″ excluding shaft and brake
Diameter . . . . . 1.50″
Brake . . . . 400-cycle brake optional

A-C & D-C TACHOMETER GENERATORS

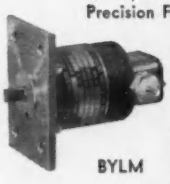
For Commercial Installations



Type AYAE a-c reversible shaded pole motor acts as a low-cost, rugged, accurate, and dependable a-c tachometer or rate generator.

AYAE

Precision For Military Usage



BYLM and FYLM generators are capable of output voltages up to 40 volts per 1000 rpm, with high linearity and low ripple content. Excellent for servo rate feed back.

BYLM

6-115V D-C PRECISION PERMANENT MAGNET, REVERSIBLE MOTORS FOR AIRBORNE AND INDUSTRIAL APPLICATIONS

BYLM

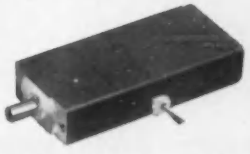
Specifications:
Rated horsepower . . . . . up to 0.1 intermittent duty
Rated speed . . 5,000 to 20,000 rpm
Power input . . . . . 7 to 155 watts
Length . . . . . 2.19″ to 3.19″ excluding shaft
Diameter . . . . . 1.50″

FYLM

Specifications:
Rated horsepower . . . . . up to .055 intermittent duty
Rated speed . . 5,000 to 20,000 rpm
Power input . . . . . 2 to 70 watts
Length . . . . . 1.77″ to 2.40″ excluding shaft
Diameter . . . . . 1.25″
Features . constant brush pressure; R3 bearings; 3/16″ dia. shaft.

DYLM — EYLM

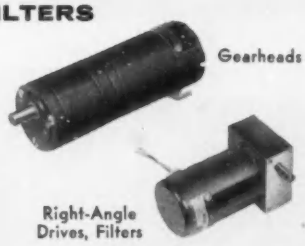
Specifications (EYLM only):
Rated horsepower . . . . . up to .055 intermittent duty
Rated speed . . 5,000 to 20,000 rpm
Power input . . . . . 7 to 155 watts
Length . . . . . 1.83″ to 2.45″ excluding shaft
Diameter . . . . . 1.38″
DYLM is a split series motor in the same envelope.



GYLM with Matching gearhead

Specifications:
Rated horsepower . . . . . up to .040 intermittent duty
Rated speed . . 2,000 to 24,000 rpm
Power input . . . . . 3 to 60 watts
Length . . . . . 1.97″ excluding shaft and gearhead
Diameter . . . . . .75″ x 1.63″
Remarks . . . Rectangular gearhead optional, as illustrated.

BLOWERS, GEARHEADS, RIGHT-ANGLE DRIVES, FILTERS

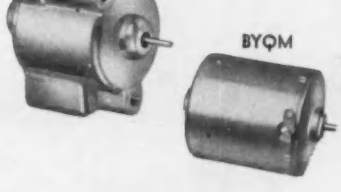


Gearheads

Right-Angle Drives, Filters

Barber-Colman d-c motors can be adapted to a variety of uses. Several sizes and styles of blowers and gearheads are available. Right-angle drives and multiple-shaft outputs can also be had for special applications. Radio noise filters furnished if desired.

D-C BATTERY-OPERATED ECONOMY MOTORS



AYQM

BYQM

Specifications:
Rated horsepower . . up to 0.5 watt continuous
Voltage . . . . . 4.5 to 30 V d-c
Rated speed . . . . 1200 to 6000 rpm (governed)
Power input . . . . . 1 to 5 watts
Length . . . 1.54″ to 1.69″ excluding shaft
Remarks . . Patented integral governor for battery operation. Reversible.

BARBER-COLMAN COMPANY

Dept. C, 1248 Rock Street, Rockford, Illinois

16 lb

Lear linear actuator is designed specifically for heavy duty industrial application. The

Exactuator

reflects 20 years actuator design and manufacturing experience by Lear. It

moves 1 ton

or less with a manually-adjustable stroke

...with speed

at the rate of one-half inch per second. Holds 3000 lbs. without slipping

and

with complete reliability. Without significant over-coast can be positioned with

precision

MAXIMUM OPERATING LOAD:
1,400 pounds tension and compression.

STALL LOAD:
2,000 pounds minimum.

MAXIMUM STATIC LOAD:
3,000 pounds tension and compression.

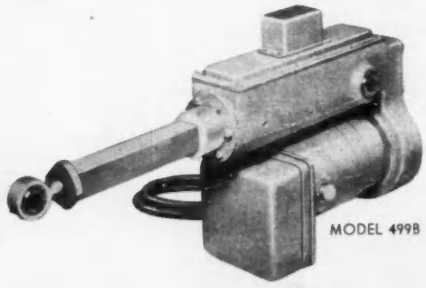
ULTIMATE STATIC STRENGTH:
5,000 pounds tension and compression.

SPEED:
0.5 inch per second with 500 pound load (3.5 Amperes); 0.15 inch per second with 1,400 pound load (5.5 Amperes)

MOTOR DATA:
0.14 horsepower at 5,000 rpm, 115 volts, 60 cycles, single-phase.

For complete information or other designs with special application to your industrial problem consult your nearest Lear Sales Engineering Office, or write:

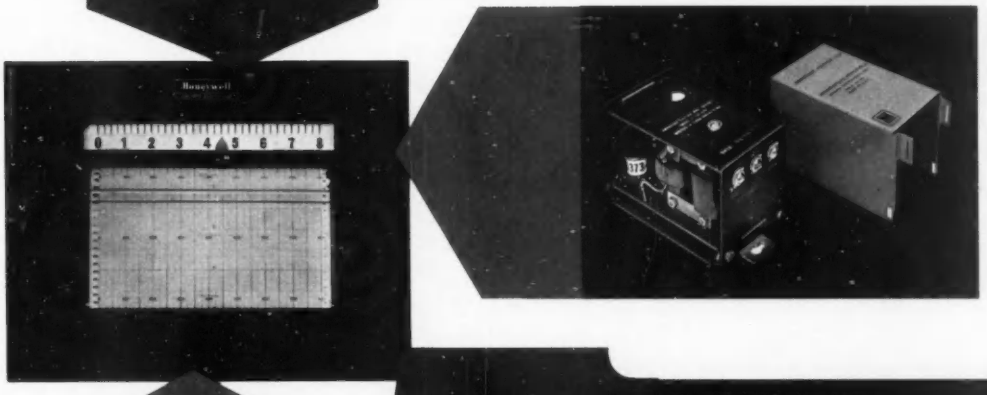
LEAR INDUSTRIAL PRODUCTS
ELECTRO-MECHANICAL DIVISION
110 Ionia Avenue, N.W., Grand Rapids 2, Michigan



MODEL 499B

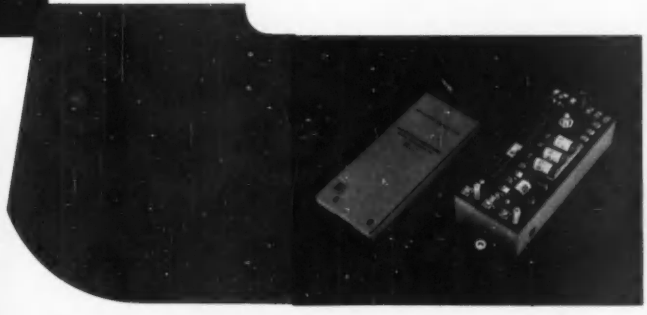
MODULAR DESIGN MAKES 1960 *Electronik* POTENTIOMETERS A GREATER VALUE THAN EVER

BALANCING AND CHART DRIVE MOTORS are sectionalized. Service is simplified because any major part can be replaced in a matter of seconds.

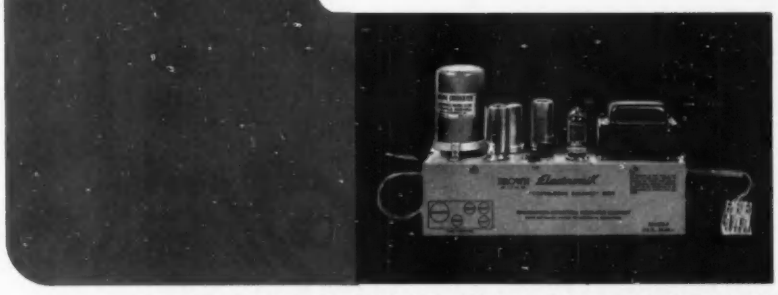


CONSTANT VOLTAGE UNIT* eliminates need for batteries, standard cells, and standardizing mechanisms . . . insuring long life.

*Zener Diode

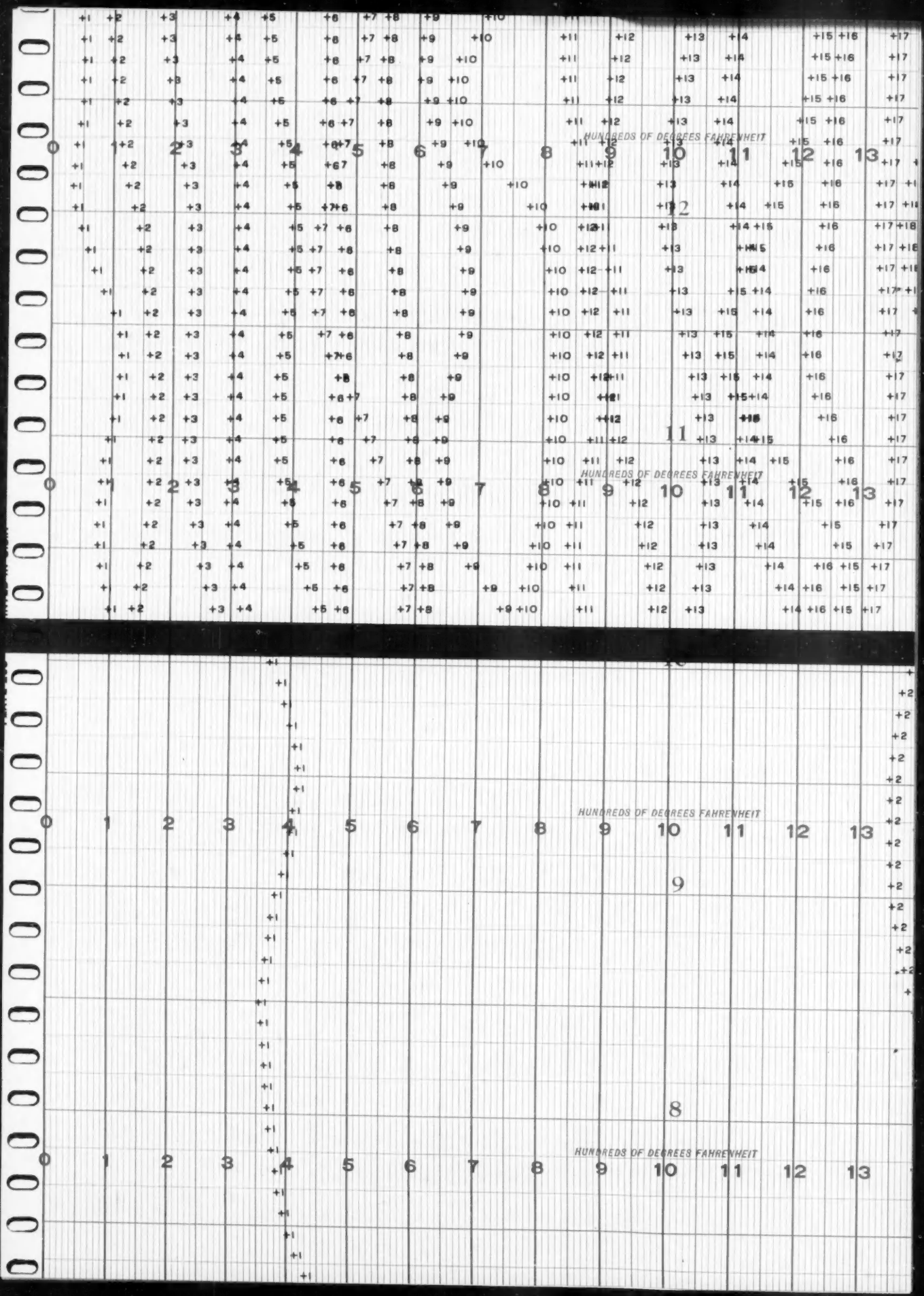


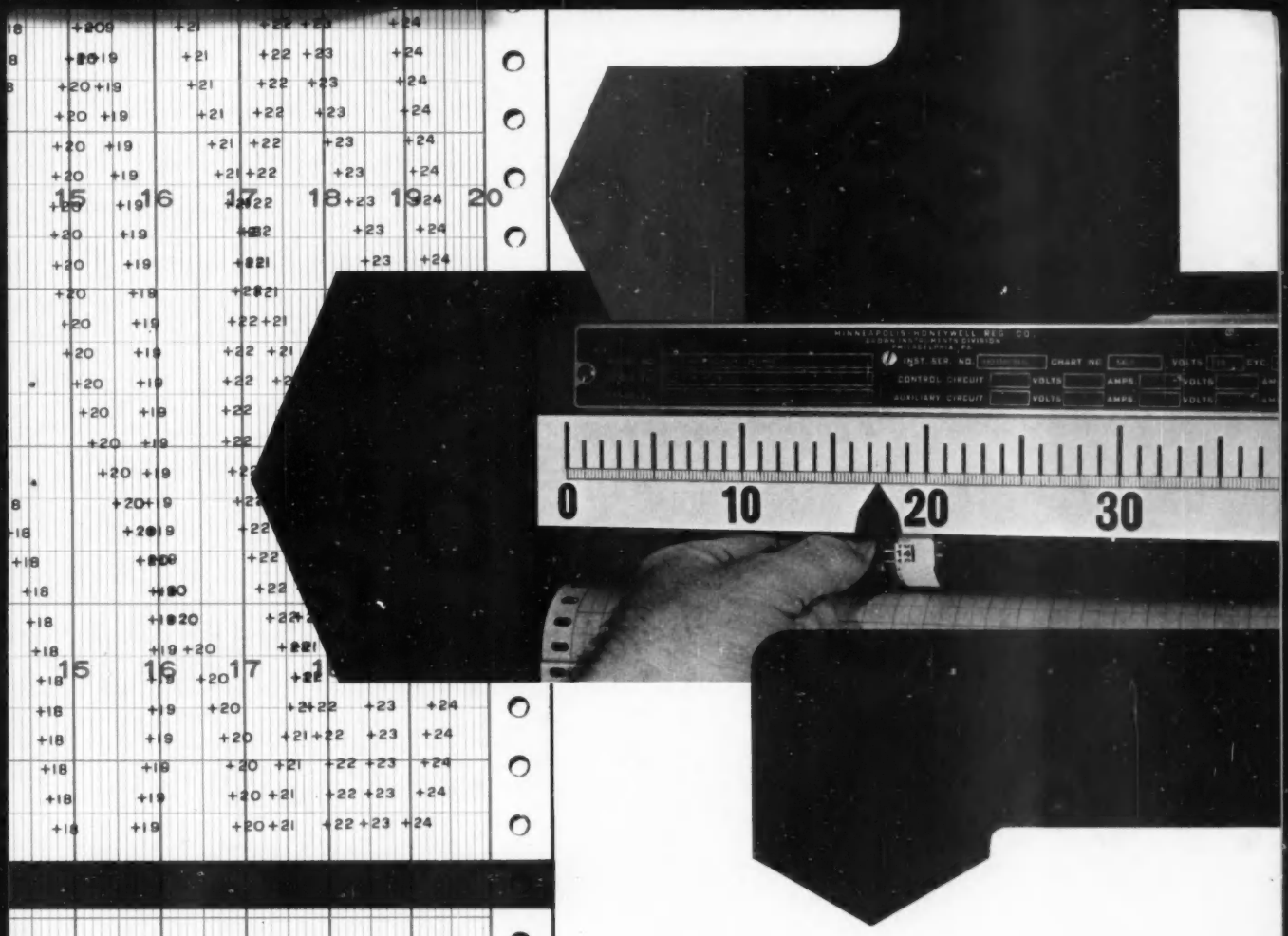
COMPARTMENTED MEASURING CIRCUIT UNIT makes range changing easy. Change one screw on a clip connected card of fixed resistors, and the job is done in a matter of seconds.



QUICK-CONNECT AMPLIFIER is easily removed from the instrument by means of a polarized plug.

BUT THIS IS JUST PART OF THE STORY OF THE 1960 LINE OF ELECTRONIK POTENTIOMETERS. LOOK AT THE DRASTIC CHANGES IN THE ELECTRONIK MULTI-RECORD RECORDERS.


HUNDREDS OF DEGREES FAHRENHEIT
0 1 2 3 4 5 6 7 8 9 10 11 12 13
HUNDREDS OF DEGREES FAHRENHEIT
0 1 2 3 4 5 6 7 8 9 10 11 12 13
HUNDREDS OF DEGREES FAHRENHEIT
0 1 2 3 4 5 6 7 8 9 10 11 12 13



Record 2 to 24 points on one instrument with new UNIVERSAL *ElectroniK*

MULTI-RECORD INSTRUMENT

Now, you can record 2,3,4,6,8,10,12,16,20, or 24 points on one ElectroniK Multi-Record Instrument... and change the number of points to be recorded in a matter of seconds. It's easy as this: remove a thumb-tight nut and slip off old print wheel . . . and indicator dial. Slip on a new wheel and dial: Replace nut. Plug in the number of points desired, and the job is done.

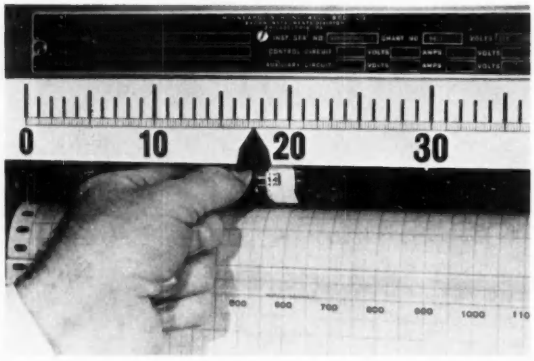
The universal features and modular design of the 1960 line of ElectroniK potentiometers are standard on all multi-record non-control models. Range and compensation changes are quick and easy, too . . . just change the cards.

FROM HONEYWELL... A DIAMOND JUBILEE PARADE OF PRODUCTS

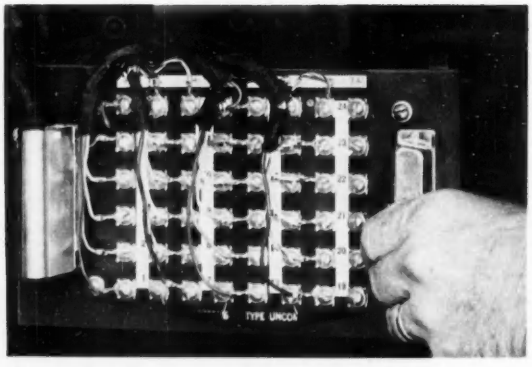
SEE HOW EASY THE 1960 ELECTRONIK MULTI-POINT RECORDERS ARE TO USE...

all it takes with the 1960 *ElectroniK* MULTI-RECORD RECORDERS to change . . .

. . . number of points recorded



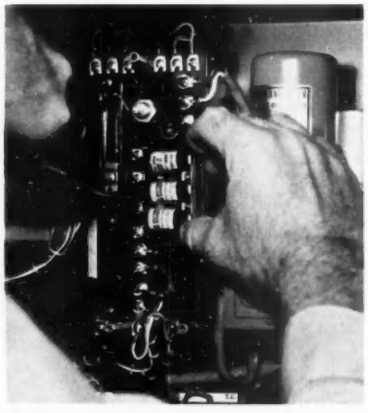
First: remove thumb-tight nut; slip off print wheel and indicator dial. Slip on new wheel and dial and replace nut.

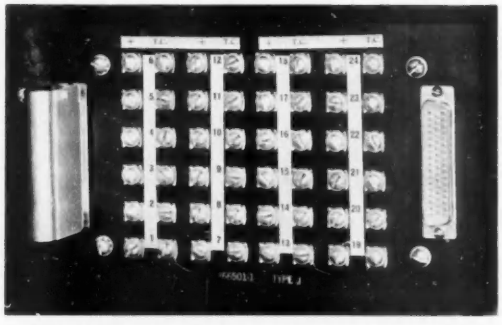


Second: replace one plug-in unit and the instrument is ready to record a different number of points.

The new flexibility and convenience of the 1960 ElectroniK Multi-Record Recorders should interest you. This new design has resulted in substantial manufacturing cost reductions which are reflected in our new price structure. Your nearby Honeywell field engineer has the full details. He's as near as your telephone. Minneapolis-Honeywell, Wayne and Windrim Avenues, Philadelphia 44, Pa.

. . . RANGE—Loosen screws and slide out the range resistor card. Replace with a different card, tighten screws and the job is done quickly and easily.





. . . COMPENSATION—The input terminal board with built-in reference junction comes out by removing one plug. Slide in the new board, replace the screws and plug and the compensation is changed.

Honeywell

First in Control

SINCE 1885

75th YEAR

PIONEERING THE FUTURE

Bypass Loop Helps Temperature Controller Maintain 1-Deg Control

W. E. ELLSWORTH
Industrial Manufacturing Corp.

With a simple design idea, an on-off bulb-and-capillary controller can hold the temperature in a water recirculation system within an accuracy normally attainable only with more complex and expensive systems. The idea is to install the controller bulb in a bypass line where relatively rapid thermal changes enable the controller to respond more quickly, anticipate the changes in the main volume of water, and thus get hairline control.

This approach is incorporated in the Thermolator units manufactured by Industrial Manufacturing Corp. for controlling mold temperature in plastics molding and forming presses. The mold temperature is maintained by heat transfer with water maintained at the desired operating temperature and pumped continuously through channels inside the mold body. Rapid heat transfer and uniform temperature throughout the mold is obtained by high pumping rates.

The Thermolator (Figure 1) is basically a closed system which heats or cools the recirculating water as required by the outlet temperature from the mold. Heat is added by an immersion heater in the water tank; cooling is provided by blending with water from the plant service line. If water is added, an equal volume is vented through a relief valve.

The technique of controlling mold temperature by positive cooling as well as by heating produces much more precise control than the usual practice of heating the mold and relying on ambient losses and process demands for cooling. In many installations mold temperature is being maintained within 1 deg F of setpoint, which is exceptional for plastics equipment. In plastics molding, constant operating temperature pays off in shorter press cycles and virtual elimination of rejects due to temperature fluctuations.

Basic components in the Thermolator are: a water tank, an immersion heater, a ⅜-in. line for cooling water, and a centrifugal circulating pump. Heating and cooling are controlled by a dual-switch Series 541 bulb-and-capillary type temperature controller manufactured by Fenwal. Two complete parallel systems are used for controlling the upper and lower halves of the mold independently.

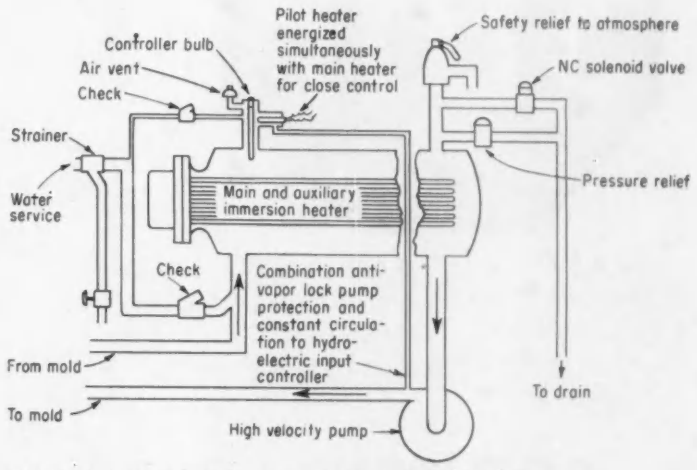
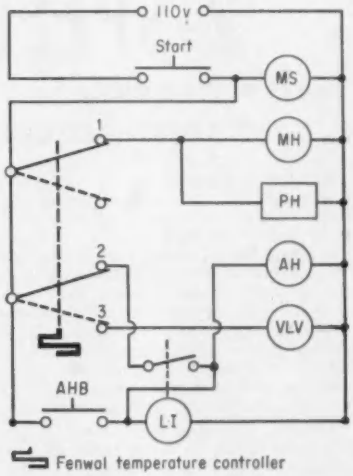


FIG. 1. Hydraulic circuit shows temperature sensing bulb in ½-in. bypass line where it senses only a sample of the flow. Small volume of water in bypass heats, cools more quickly than large volume.

Bypass line is key

Since the mold temperature is governed entirely by heat exchange with rapidly circulating water, rapid correction of water temperature is essential. This is accomplished by having the temperature controller sense only a sample flow rather than the entire volume of water. The sensing bulb is installed in a ½-in. line which forms a loop from the outlet side of the pump back to the tank, see Figure 1. In this line—ahead of the sensing bulb—are installed a 200-watt heater and a ¼-in. cold water inlet, which actuate at the same time with the large heater and water delivery in the main tank. An 0.070-in. orifice in the bypass loop provides constant line flow regardless of fluctuations in pumping head.

Under the influence of the pilot heater and water inlet, the relatively small volume of water in the bypass



Fenwal temperature controller
MS Motor starter
MH Main heater current
PH Pilot heater
AH Auxiliary heater current relay
VLV Solenoid valve current relay
LI Lock-in relay
AHB Auxiliary heater button

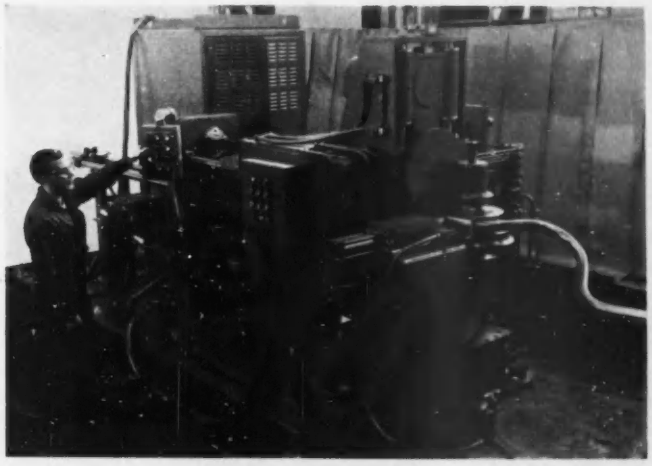
FIG. 2. Simplified wiring diagram of one of two parallel electrical heating and cooling circuits, see text.

loop heats and cools more rapidly than the water in the main tank. As a result the temperature controller can respond sooner than if installed in the tank and anticipates a control action that will be needed 5 to 10 sec later. This solves the problem of close temperature control in a large mass of material having a high heat capacity (such as water), whose thermal inertia causes a certain amount of "coasting" past the control point before the corrective action takes hold. With the heating and cooling inputs located just ahead of the controller bulb, the controller's response time is reduced, and the cycling rate is increased. This causes the correction to be delivered in short bursts, rather than prolonged cycles, greatly reducing the possibility of overheating or overcooling.

The heating and cooling circuits are both handled in the controller by a pair of two SPDT switches, Figure 2. One switch controls the heater power circuit; the second switch, set to actuate about 2 deg higher, controls the solenoid valves for cooling water. The 2-deg dead zone between the two prevents simultaneous actuation of the heating and cooling circuits.

Higher heat input is required on start-up to reduce the warm-up time than when operating at the control temperature. The heating circuit is therefore designed to deliver full heater capacity during warm-up and to reduce heat input by $\frac{2}{3}$ once the operating temperature is reached. This is accomplished by using a three-phase heater and deenergizing two phases by releasing a latching relay.

Punched Tapes Shape Auto Tailpipes



Tailpipe emerges from delivery end of Bend-O-Matic. Hydraulic cylinder at center of picture holds wiper block against pipe.

The numerically controlled bending machine promises to relieve a major problem for the automotive repair-parts distributor. This is the warehousing of large stocks of the approximately 750 different shapes and sizes of exhaust tailpipes required to fit the array of cars now on the road. A distributor having the new Bend-O-Matic needs only a supply of straight pipe sections and a file of punched tapes, one for each model of automobile. Under tape control, the machine makes straight pipes into tailpipes.

As designed by the Baldwin-Lima-Hamilton Corp., the machine bends pipe by feeding it between a pulley-like die and a rocking wiper block. As the pipe is inched forward, the block reciprocates around the periphery of the die, gradually bending the pipe into the pulley groove. The direction of bending is changed simply by rotating the clamp that holds the pipe.

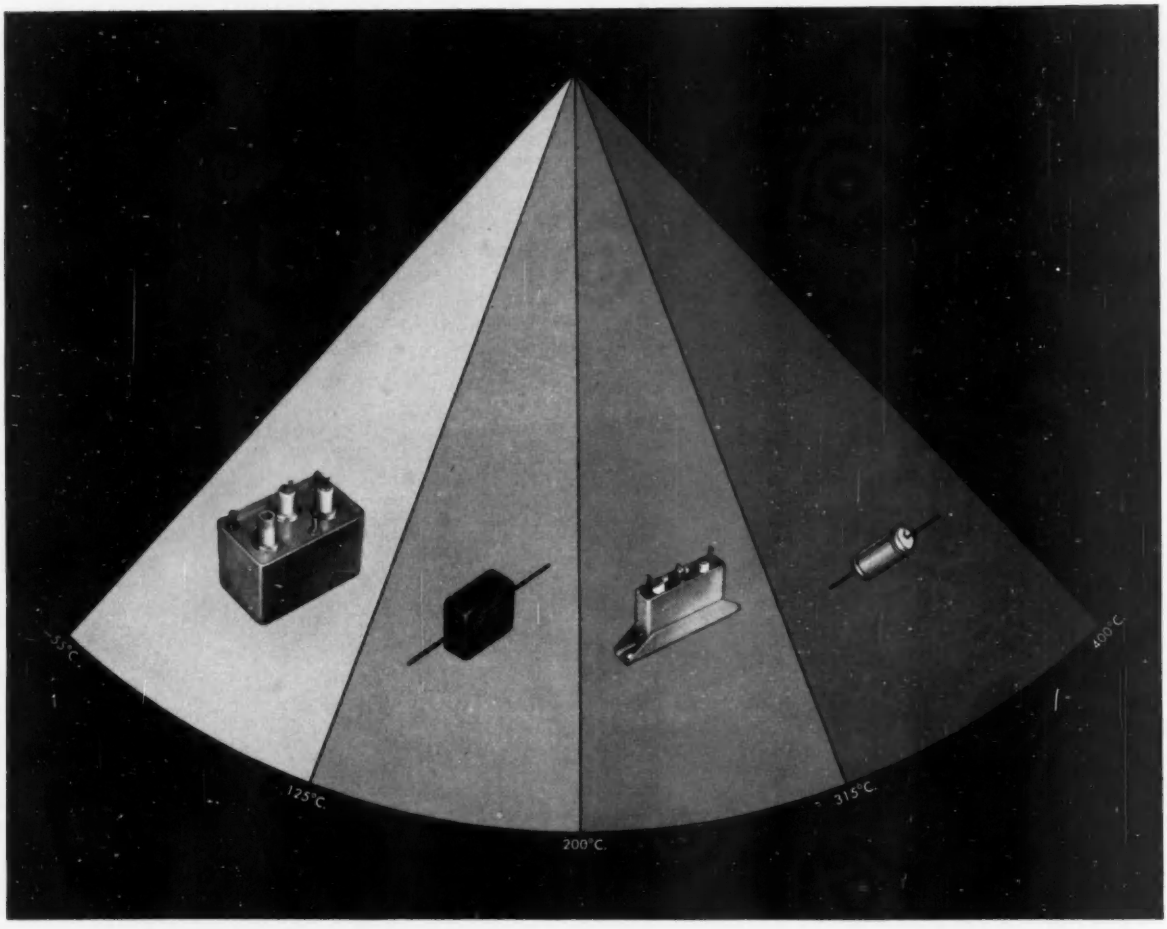
The numerical control is a modified General Electric Co. Mark III point-to-point positioning system which can handle three independent motions simultaneously. The first controlled motion is the pipe feed, which is continuously adjustable from very small increments where sharp bends are to be made to rapid traverse steps at 600 ipm where no bends are required. The pipe is held in a hydraulic clamp that engages a leadscrew powered by a $\frac{1}{2}$-hp electronic adjustable speed dc drive. Clamp position is fed back to the control by means of synchros.

The feed sequence begins with the clamping of the pipe at a signal from the input tape. Next, the feed motor is energized until the clamp has moved forward through the programmed distance with an accuracy of plus or minus 0.05 in. Then, while the bend is being made, the clamp unlocks and the feed motor reverses. When the clamp has been moved back a sufficent amount, it is locked again, ready to advance the pipe through the next increment. The clamp carries a separate $\frac{1}{3}$-hp dc motor and a single-synchro feedback element that permit the clamp and pipe to be turned about their axes. The input tape can be programmed to rotate the pipe through any angle up to 360 deg with an accuracy of plus or minus 1.8 deg.

The third motion controlled from the punched tape is the length of arc through which the wiper block reciprocates. Because bends are made without the use of mandrels or other fillers within the pipe, the wiper must be programmed initially to take short and then progressively longer swings to prevent the flattening that would occur if a bend were made in one long sweep. The drive for the wiper support structure is a two-speed hydraulic servo with sufficient power to supply the high bending torques involved. A single-speed synchro feedback provides bending accuracy of plus or minus 1.8 deg.

The input medium is standard 1-in. wide eight-channel punched tape. Approximately 18 in. of tape is required to program the average tailpipe. This amount of tape is enough to carry data not only for the three controlled motions but also for auxiliary functions such as die selection, clamp on and off, cycle start and stop, and operation of the cut-off saw. The machine shapes an 8-ft. length of tubing in two minutes.

The Nu-Era Corp. of Rochester, Mich., sponsored the development of the Bend-O-Matic and plans to lease the machines to local automotive distributors at an annual fee of $25,000.



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Compound Modulation Recording Keeps Strain Gage Signals Clean

H. R. DARBY
Convair-Fort Worth

A low frequency ac carrier technique has been used on the B-58 flight test program for the past three years to record strain gage transducer outputs on magnetic tape. The design was prompted by certain deficiencies in other methods commonly used to transform these transducer outputs into FM signals for recording on tape.

In sharp contrast to a flight test missile, the typical program of a B-58 flight test airplane takes two to four years and 100 to 150 flights with 50 to 100 measurements involving strain gages on each flight. Transducers are often so inaccessible that it is not feasible to apply artificial stimulus for "onboard" calibrations. Since ranges given in the function description may be in error, an easy method of altering scale without changing the transducer is desirable. Most of the measurements are quasi-static; highest frequency response required is 50 cps.

The low frequency carrier technique decided upon has been called the Narrow Band/Compound Modulation (NB/CM) System. The "narrow band" is from the fact that narrow band FM is used (plus or minus 7½ percent carrier deviation), and the "compound modulation" signifies that both amplitude and frequency modulation is employed.

The NB/CM technique uses standard IRIG voltage-controlled FM oscillators (VCO) and discriminators, multiplexed in the usual way. Although designed to be used primarily with magnetic tape, the technique has been used with success on telemetering rf links as well. NB/CM is similar to any other ac carrier instrumentation system except that the balance, calibration, and amplification circuits are on the test vehicle, while the demodulators are located at the ground processing site. The amplified AM output of the transducer is converted to FM, multiplexed with other signals, and stored on magnetic tape along with a carrier reference. The ground playback process consists of demultiplexing, FM discrimination, and AM demodulation. Figure 1 is a block diagram of the system.

Figure 2 shows a functional diagram of the airborne portion of the NB/CM system. A carrier voltage of 70 to 300 cps is applied across the strain gage transducers from a centralized excitation supply. The carrier frequency is chosen to be compatible with the desired intelligence frequency response. The amplitude modulated transducer output is then passed through conventional bridge balance adjustments. It was found necessary to have both resistive and reactive balance controls for a precision balance. This adjustment is accomplished by monitoring the ac amplifier output with a VTVM and adjusting the balance controls for a minimum reading. Measuring at the amplifier output eliminates the noise and grounding problems of measuring the low level transducer output.

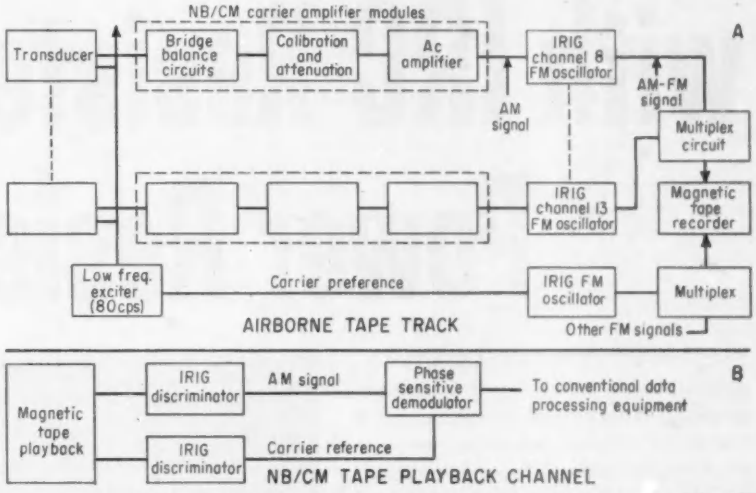

FIG. 1. A—Narrow Band/Compound Modulation recording system used in B-58 flight tests includes tape recorder in airborne equipment. B—Ground equipment discriminates FM first, then demodulates AM strain gage signal.

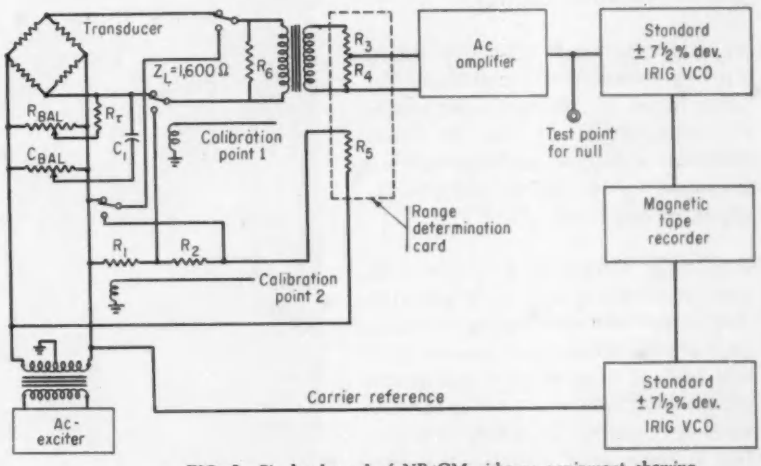

FIG. 2. Single channel of NB/CM airborne equipment showing calibration circuits by which range can be changed with plug-in card.

Transducer calibration

An indirect two-point "onboard" calibration of the measuring circuit is provided by the voltage divider formed by R_1, R_2, and R_5. The calibration is

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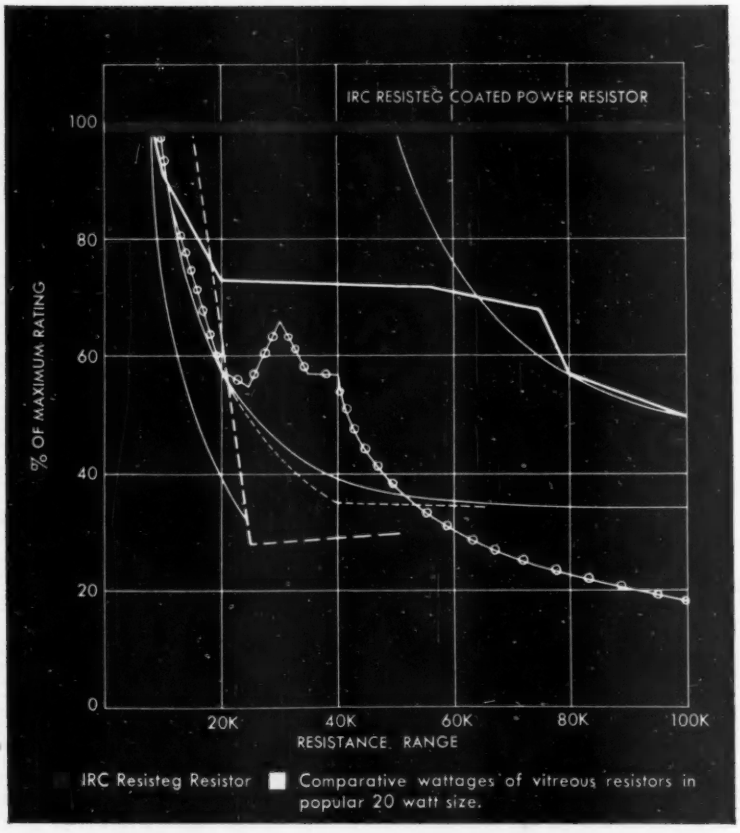

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initiated by energizing a cam-operated calibration programmer. The voltages across R_1 and R_2 are accurately known percentages of the excitation or, expressed another way, millivolts of signal per volt of excitation. The transducers are calibrated in the laboratory to establish their sensitivity in terms of stimulus/mv/volt when loaded by the 1,600-ohm input impedance of the ac amplifier. By multiplying the transducer calibration constant by the "on-board" calibration ratio, the physical meaning of the calibration excursion is determined. Numerous tests have proved that this indirect slope calibration technique is accurate to 1 percent. Calibration resistor R_5 and attenuator resistors R_3 and R_4 are precision fixed resistors on a removable printed circuit card. Range can be altered by changing the card. As sensitivity is increased, the transducer drift becomes a larger percentage of full scale error; but for many dynamic measurements this is of no consequence. Usually the scale may be doubled without exceeding the accuracy called for in the measurement function description.

After passing through the input balancing and calibration circuits, the amplitude modulated signal is amplified by a stable ac amplifier. The amplifier output is 5 volts peak to peak biased to 2.5 vdc. The bias permits operation of the voltage control oscillator about its center frequency and serves as a signal source when making FM oscillator adjustments. IRIG channels 8 through 13 are used with an 80-cps carrier. The data frequency response of this combination is 12 cps. Channels 11, 12, and 13 are used with a 180-cps carrier to give a frequency response of 30 cps. A 300-cps carrier is used with channel 13, which has a frequency response of 50 cps.

The oscillator outputs are multiplexed and recorded on a tape track. For the ground demodulation process a carrier reference is recorded by a standard FM oscillator and multiplexed on a tape track along with other signals. One reference (and usually a backup) is recorded on each tape and used to demodulate all carrier signals on that tape.

During ground playback the AM-FM signal is first discriminated by standard IRIG discriminators with low-pass output filters. For instance, nominal 100-cps filters are used on IRIG channels 8 to 13 when the 80-cps carrier is employed. These filters have staggered cut-off frequencies to compensate for the difference in time delay in the band-pass filters used for demultiplexing. This puts the AM signals in phase with each other and with the carrier reference at the discriminator outputs to ready them for amplitude demodulation.

Commercially available demodulators as well as Convair designed demodulators are used for the demodulation process. All have an inherent rejection of static drift in the FM oscillators and discriminators. The combined filtering of the discriminator low-pass output filters, the demodulator output filters, and the inherent rejection of low frequency noise (such as flutter) by the demodulators results in a rather clean signal. In fact, low level signals have been recovered by "blowing up" the scale on playback as much as five times.

After amplitude demodulation the data is processed with conventional data processing techniques, i.e., presented on pen recorders, converted from analog to digital for computer processing. On the B-58 airloads survey an analog computer is used to process the data. In this application demodulators that are servo gain controlled are used to standardize the scale factors before computing.

Automatic Resistance Measurement System

ROBERT M. WALKER
University of California, Livermore

In a study of high temperature aging effects on certain alloys, resistance measurements were chosen as the primary technique. Current and potential leads are welded to a small bar of the test alloy and the sample heated to an accurately controlled temperature for the duration of the test. The tests last up to 1,000 hr with aging temperatures of 1,400 deg F.

To reduce supervision and computation, the measurement system operates automatically, producing output data in digital form on punched tape suitable for direct computer entry. Calculations and graph plotting are done by digital computer. Resistance is measured by comparing the voltage drops across the sample and a standard 1-ohm series resistor. The voltage ratio equals the resistance ratio. Using a 1-ohm standard resistor makes the voltage ratio numerically equal to the sample resistance in ohms.

A digital ratiometer can be used to measure this voltage ratio, as in Figure 1. But commercial digital ratiometers are three-terminal devices with a common input connection. Connected as in Figure 1, current would flow in the two potential leads and cause large errors due to the *IR* drops in the leads. The solution was to add a commercial differential type isolation amplifier in one leg of the circuit, Figure 2. Temperature induced emf's generated at the junctions of the dissimilar metals of the metallurgical sample and the potential leads were eliminated by taking two ratiometer readings for each sample in reverse current directions. The two readings are then averaged to cancel all voltages other than *IR* drop.

In the complete system a stable low voltage power supply is connected through a current-reversing relay to a series load of five metallurgical samples and a 1-ohm standard resistor. The resistances of the samples range from 0.01 to 0.1 ohm. The samples are connected to the ratiometer one at a time through a stepping switch. When the ratiometer reaches a steady reading, the digital value of resistance and the sample number are selected by a second stepping switch and punched one at a time on paper tape. A timer controls the readout.

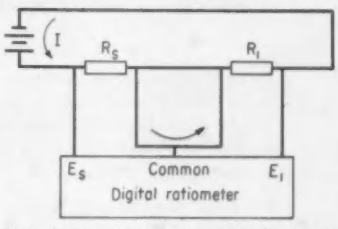


FIG. 1. Use of ratiometer and 1-ohm standard resistor to measure resistance of sample.

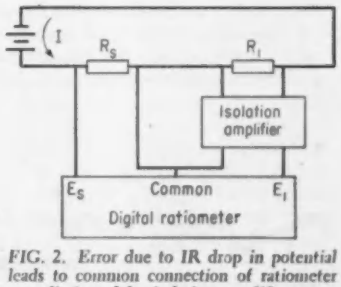
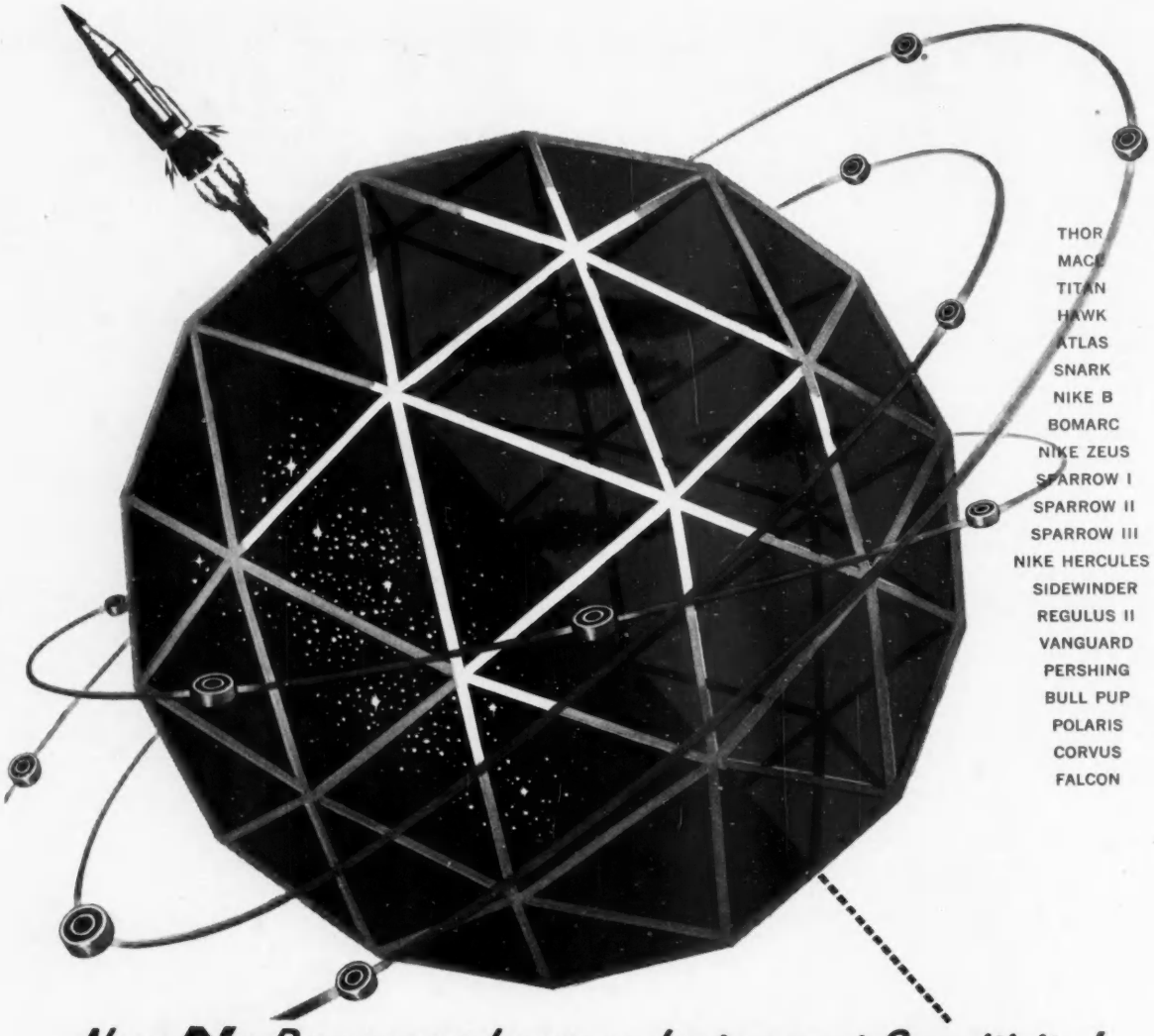


FIG. 2. Error due to IR drop in potential leads to common connection of ratiometer was eliminated by isolation amplifier.



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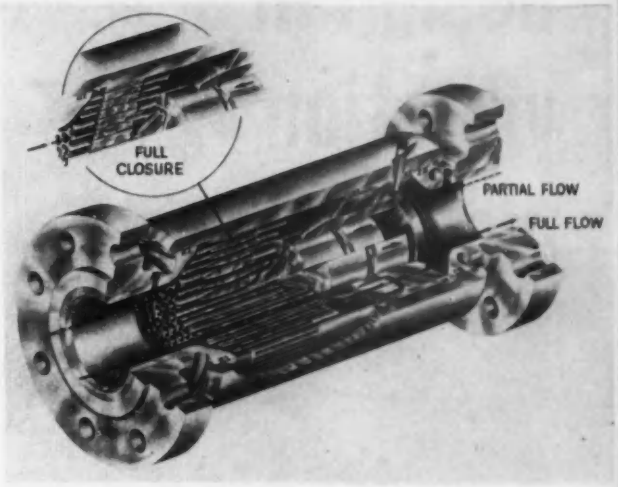
SILENT VALVE DESIGN
offers smoother flow control.

Conceived and developed by Aerojet's Anti-Submarine Warfare Div., this new valve design virtually eliminates aeration, cavitation, surging, vibration, and noise, all of which are associated with rapid changes in flow conditions.

Heart of the valve is a molded cylindrical elastomer insert with multiple axial holes that serve as flow passages. This is mounted within the valve body between two perforated plates having matching hole patterns. To throttle the flow, a hydraulically actuated piston drives one of the plates to compress the elastic insert, thereby reducing the diameter of the flow passages. Artist's cutaway sketch at the right illustrates simultaneously the full, partial, and zero flow conditions.

Manufacturer feels that, aside from its advantages in submarine applications, valve could boost efficiency and cut maintenance costs in many industrial applications.—Aerojet-General Corp., Azusa, Calif.

Circle No. 280 on reply card



THERMOELECTRIC COOLERS
solve critical hot spot problems.

Photo at right shows a variety of thermoelectric cooling devices now being produced in commercial quantities. Units should be ideal for use in flight control and guidance systems where high component densities create dangerous hot spots. They are compact, operate quietly, have no moving parts, and provide a controlled cooling rate. Heat pumping capacities depend on the temperature gradient across the cooler surfaces and on the input power. A Type WX816 module, for example, will maintain a 25 deg C differential with a heat load of more than 17 Btu per hr.—Westinghouse Electric Corp., Pittsburgh, Pa.

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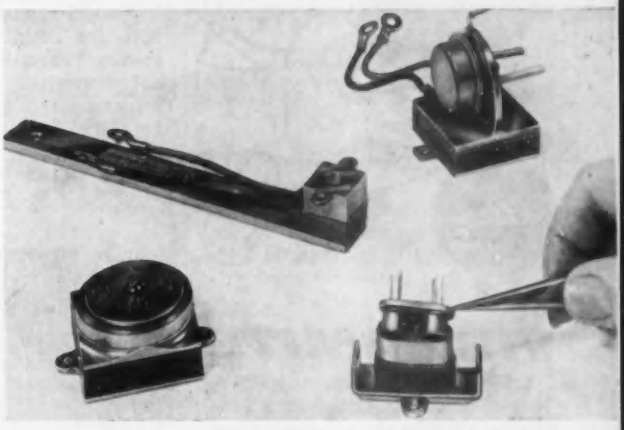

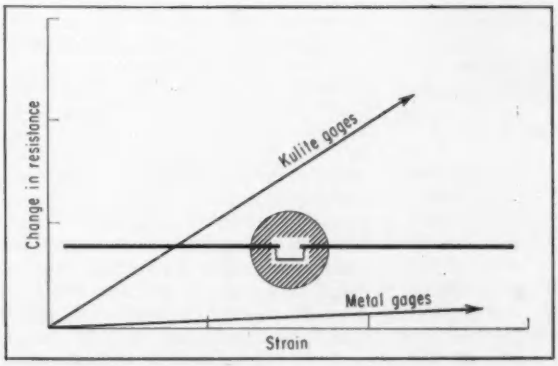

STRAIN GAGE uses semiconductor.

An outgrowth of basic research at Bell Telephone Labs and now commercially available, a new line of semiconductor strain gages offers users gage factors up to 100 times greater than comparable metal wire and foil gages. Maker claims these new units will simplify strain gage instrumentation and permit strain measurements heretofore impossible or extremely difficult.

First of the line, the Type DA-101, features a nominal resistance of 70 ohms and a gage factor of 115. Overall dimensions are $\frac{1}{8}$ by $\frac{1}{4}$ in. exclusive of rugged nickel leads. Other models with these same basic dimensions will have resistance values ranging from ohms to megohms.—Kulite-Bytrex Corp., Newton, Mass.

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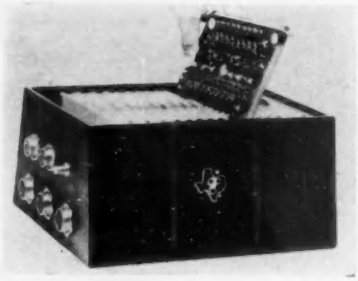
NEW PRODUCTS

DATA HANDLING & DISPLAY



COMPACT DESIGN

Solid state throughout, this 25-lb PCM telemetry system for missile and space vehicles occupies just ½ cu ft of space. The system multiplexes and encodes 64 analog channels and processes five eight-bit parallel digital data channels plus a serial digital data channel at a nominal bit rate of 200 kc. Its high-speed multiplexer uses a single low level amplifier yet handles both low- and high-level data. A unique bidirectional servoloop nulls out system drift to provide an overall accuracy within 0.25 percent.—Apparatus Div., Texas Instruments, Inc., Dallas, Tex.

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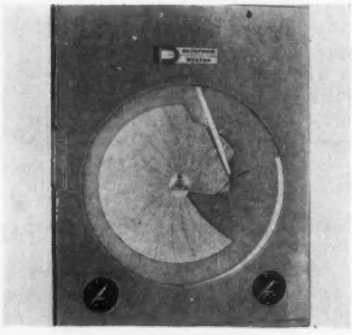


PROGRAM TRANSMITTER

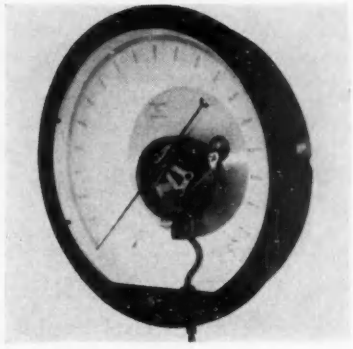
Interchangeable cam drives for this Model 7002 pneumatic program transmitter offer the user a choice of five time cycles: 1, 8, or 12 hrs, 1 or 7 days. Unit transmits a 3- to 15-psi signal and can be used with double cams to handle two separate transmission systems. Its casing measures 14⅞ in. wide by 18¾ in. high. Flush mounting leaves less than an inch of case front projecting.—Weston Instruments Div., Daystrom, Inc., Newark, N. J.

Circle No. 284 on reply card

DIGITAL-TO-ANALOG

The new EI4700 Series Dataverters are designed to translate digital data from punched cards, punched paper tape, and magnetic tape into analog voltages to operate the company's line of X-Y plotters. Units also generate control signals for both the input devices and the plotters. Output features include scaling and symbol generation. Its completely solid state circuitry uses both magnetic core and transistor logic.—Electro Instruments, Inc., San Diego, Calif.

Circle No. 285 on reply card



HIGHLY PRECISE

Accuracy within 0.1 percent of full scale reading has now been extended to pressure gages in the 50,000-psi range. Significant design features of these new gages include a unique one-piece stainless steel helical tube and a new bimetal thermal compensator which makes pressure readings insensitive to temperature variations within a 100 deg F range.—Heise Bourdon Tube Co., Newtown, Conn.

Circle No. 286 on reply card

INDICATES AND TRANSMITS

Designed for use in low to medium pressure systems, the Model 231 indicating transmitter provides local (within 300 ft) pressure indication and simultaneously transmits a proportional electrical signal for driving a remote recorder. Unit will measure air of noncorrosive gas pressures or drafts over ranges from 0-0.2 in. to 0-120 in. water and will handle static pressures up to 65 psig.—The Hays Corp., Michigan City, Indiana.

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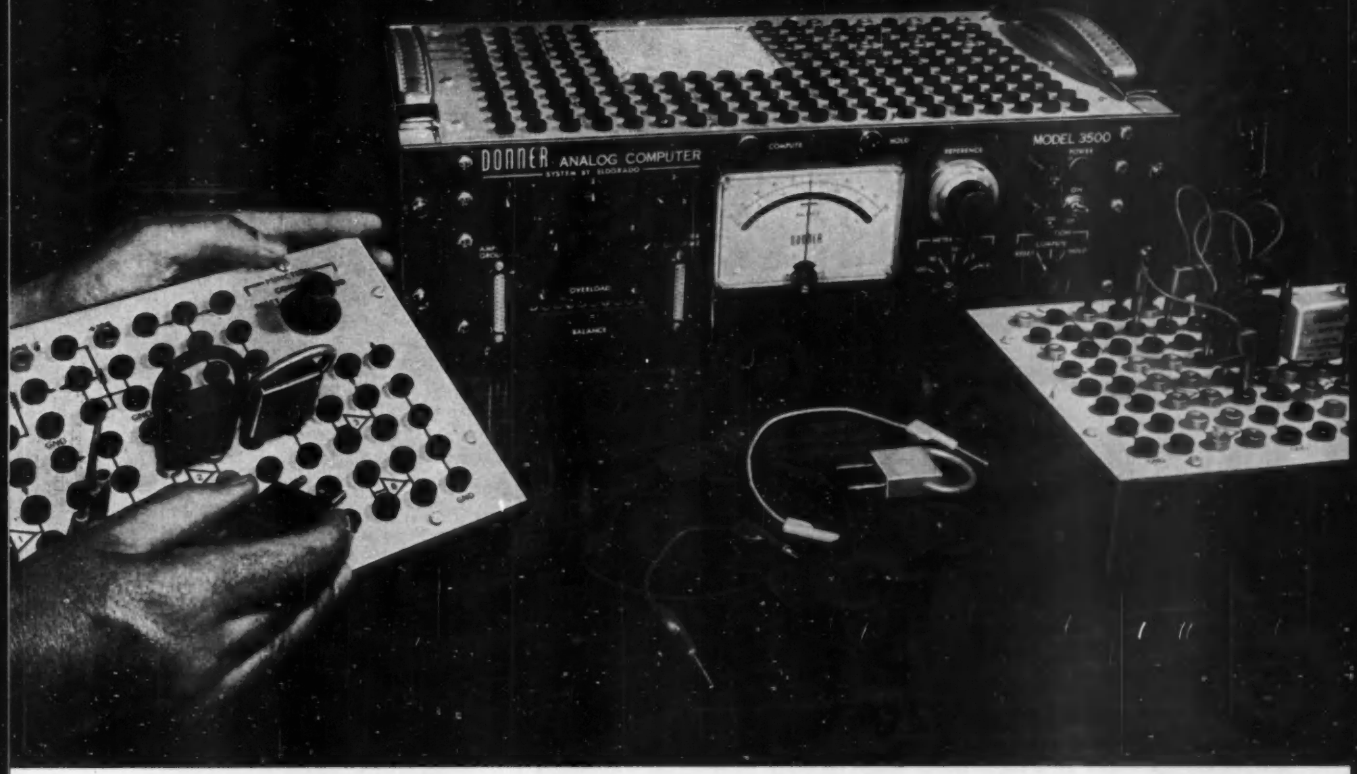
The New Donner 3500



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NEW PRODUCTS

PLUS. . . .

(288) The solid state 7080 **data processing system** recently announced by **IBM Corp.**, White Plains, N. Y. offers processing speeds up to 10 times faster than IBM's 705 systems. . . . (289) Another solid state entry, an **electronic supervisory control system** designed and built by **Southwestern Industrial Electronics Co.**, Houston, Tex., provides pushbutton control for oil well test and production operations. . . . (290) **Tipptronic, Inc.**, Chagrin Falls, Ohio has introduced a **modular temperature scanner** that will monitor up to 50 thermocouple or thermistor sensing elements.

Circle Nos. 288, 289, or 290 on reply card

RESEARCH, TEST & DEVELOPMENT

FLAT TO 500 CYCLES

Priced at $395, this Model 300BF differential transformer indicator handles both static and dynamic measurement. A demodulated output, flat up to 500 cps, is available for operating cathode ray and recording oscillographs; static, slowly varying, and average values are displayed on a 10-in. panel meter. Applications include indication and recording of linear motion, acceleration, force, and any other variable that can be used to position the core of a differential transformer.—Daytronic Corp., Dayton, Ohio.

Circle No. 291 on reply card

VERSATILE SCANNER

A new infrared scanning system, called Filterscan, provides a television-type image of heat-emmissive targets detected by IR cells. Industrial applications of this system include monitor-

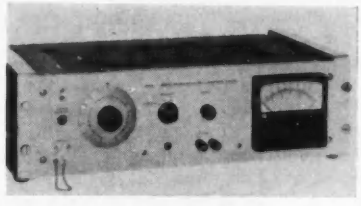
ing of equipment which might develop damaging hot spots, inspection of components leaving an assembly line, and inspections of closely packed electronic systems. Military applications are still under security wraps.—Philco Corp., Philadelphia, Pa.

Circle No. 292 on reply card

CHECKS SHOCK

This Model A12 accelerometer, designed for recording shocks on recovery parachutes, landing gear, delicate instruments, and other equipment, uses a deformable plastic filament mounted between a glass window and an internal seismic mass. Deformation of this filament over a short duration shock indicates magnitude of the shock. Replaceable premounted filaments with direct reading scales are readily installed. Unit has a linear range of 10 to 50 g's and a usable range of 5 to 125 g's.—Pace Engineering Co., North Hollywood, Calif.

Circle No. 293 on reply card



COVERS 17 RANGES

Specifically designed for production tests, monitoring installations, and laboratory measurements, this Model 414 micromicroammeter covers 17 full scale dc current ranges between 10 ma and 100 $\mu\mu$a. Accuracy is within 3 percent of full scale down to 10 μa. Additional features include a 5-volt output at up to 1 ma. a 0.2 sec response time, and optional contact meter variations. Standards unit sells for $280.—Keithley Instruments, Inc., Cleveland, Ohio.

Circle No. 294 on reply card

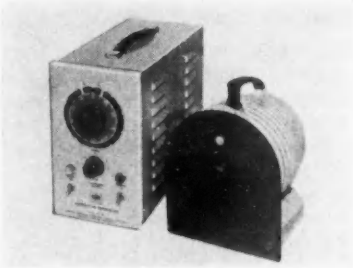
PORTABLE CABLE TESTER

A new bench-top multiconductor cable tester, designed to check out cables of up to 96 conductors for both hi-pot and continuity, is made in two

NEW PRODUCTS

separable sections and can be used for testing in-place cables when both cable ends are accessible. Three hi-pot test voltages are available: 500, 1,000, and 1,500 vdc, with minimum insulation resistance settings of from 1 to 5 megohms. A 96-light indicator panel provides instantaneous indication of continuity.—Leemath Inc., Syosset, N. Y.

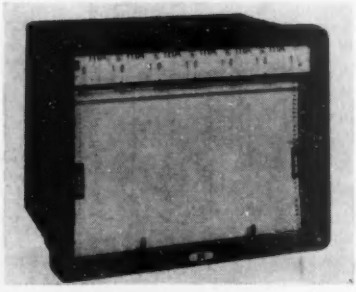
Circle No. 295 on reply card



CHECKS IR SOURCES

The combination of the ISL black body and the ISL 100 temperature controller represents an accurately adjustable standard of radiant energy, ideal for checking and calibrating other infrared sources and measuring instruments. Unit covers the temperature range of 500 to 1,000 deg K. Stability of the controller maintains radiation source temperature within 1 deg K despite wide changes in ambient temperature, line voltage variations, transients, and tube aging.—Infrared Standards Lab., Riverside, Calif.

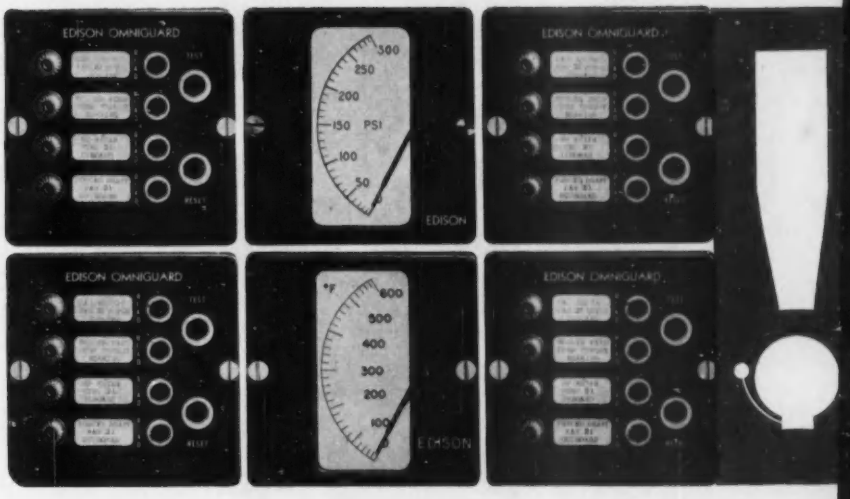
Circle No. 296 on reply card



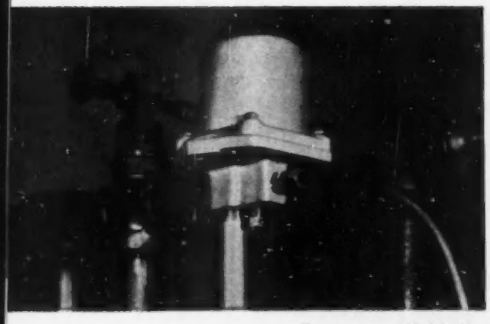
FLEXIBLE DESIGN

This new rectilinear strip chart recorder provides six independent, non-overlapping, and continuous records and is equipped with interchangeable pens for ink or inkless recording. Each channel is sensitive to 1 ma full scale

GUARD ALL CRITICAL PRESSURES AND TEMPERATURES WITH THOMAS A. EDISON LOW-COST, OMNIGUARD WARNING SYSTEM



Here is a versatile, highly-reliable continuous warning and monitoring system. By simply pushing a button on this panel you obtain a reading of *key pressure* and *temperature* points throughout your plant. In addition, this system provides instantaneous warning when pressure or temperature deviates from pre-set limits.

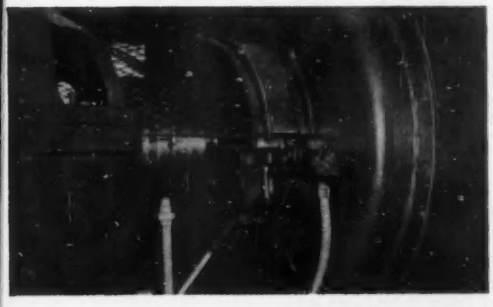


PRESSURE

With the Edison Omniguard system you can monitor gas, fluid or vapor pressure. Heart of the system is a rugged, accurate, pressure detector which converts pressure directly to electrical resistance—requires no millivolt conversion—no amplifier. For pressures under 60 PSI a precision capsule is the sensing element. From 60 to 3000 PSI special bourdon tube elements are used.

When pressure changes, resistance varies and this deviation is transmitted to the control panel. Units operate over ambient temperatures of 32° to 150°F. Control panels are available with a wide variety of scales and are equipped with both normally open and normally closed alarm contacts to operate any type of auxiliary device or to automatically shut down machinery or process.

Compact, reliable Resistance Pressure Detector transmits changes in pressure to central control panel.



TEMPERATURE

Edison Omniguard also provides reliable protection from overheating. You can monitor the temperature of bearings, gases and liquids in critical equipments or processes. Reliable Edison Resistance Temperature Detectors have no moving parts and give instantaneous warning when limits are exceeded. Unlike other systems which only scan, Omniguard is continuously monitoring. You can obtain exact readings of temperatures in all parts of your plant from one central control panel.

For greater flexibility and reliability each detector circuit is completely independent. If one circuit is damaged, all other circuits remain "on guard." When changes or additions are required they can be accomplished quickly and easily.

Rugged, accurate Resistance Temperature Detector guards against overheating of this motor bearing.

Thomas A. Edison Industries
INSTRUMENT DIVISION
38 LAKESIDE AVENUE, WEST ORANGE, N. J.

CIRCLE 173 ON READER SERVICE CARD

and features a 1-sec response time. Available chart speeds range from ½ in. per hr to 24 in. per min.—Princeton Div., Curtiss-Wright Corp., Princeton, N. J.

Circle No. 297 on reply card

PLUS. . . .

(298) **Honeywell's Rubicon Instruments Div.,** Philadelphia, Pa., now offers a redesigned line of six-dial thermofree **microvolt potentiometers** featuring both electrostatic and thermal shielding. . . . (299) A new Series of inexpensive portable **stimuli generating tables** for automatic missile, drone, and aerospace craft checkout was recently announced by **Micro Gee Products, Inc.,** Culver City, Calif. . . . (300) **The Bristol Co.,** Waterbury, Conn., has developed a laboratory version of its Dynamaster wide-strip potentiometer recorder. . . . (301) A dynamic **pressure calibrator,** developed by **Wiancko Engineering Co.,** Pasadena, Calif., provides an accurate means of measuring the transient response of pressure pickups in connecting lines.

Circle Nos. 298, 299, 300, or 301 on reply card

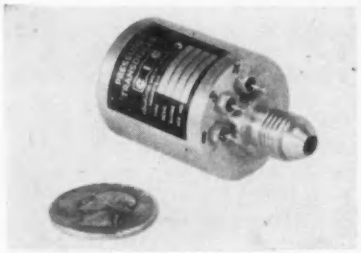
PRIMARY ELEMENTS & TRANSDUCERS

LONG-LIFE ENCODER

Using an 8½-in. plated disc, this Model C-804 shaft position encoder provides an output of 3,600 quanta per revolution in Datex code or 4,096 quanta per revolution in Gray code. Its brush contacts of precious metal alloys are designed to maintain performance despite wear. Readout requires only the application of a suitable low current voltage to the contacts. Under normal

operating conditions and with recommended maintenance, unit should have a useful life of over 10 million revolutions.—Datex Corp., Monrovia, Calif.

Circle No. 302 on reply card



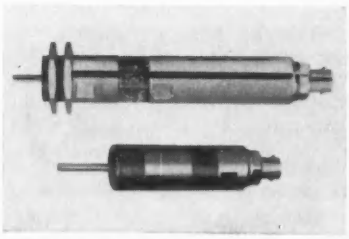
INFINITE RESOLUTION

With a diameter of 1.156 in. and a body length of 1.39 in., this Model 1000A potentiometer pressure transducer still provides virtually infinite resolution. Unit is available in ranges from 0-15 to 0-350 psi, gage, differential, or absolute.

Characteristics:

Resistance values: Up to 10 k
Linearity: To within 0.5 percent
Repeatibility: Within 0.1 percent max
Hysteresis: 0.2 percent max
Temperature sensitivity: 0.01 percent per deg C
— Computer Instruments Corp., Hempstead, N. Y.

Circle No. 303 on reply card



RAPID RESPONSE

Shown are two new displacement transducers, Models DT-2000, above, and DT-500. Units were developed for measuring linear displacements between 2.000 in. and 0.500 in. with a frequency response of from 0 to 10,000 cps.—Photocon Research Products, Pasadena, Calif.

Circle No. 304 on reply card

YIELDS SHAFT POSITION

A new high torque, electronic transducer converts pressure, level temperature, and other process measurements into a shaft position for operating transmitting slidewires, alarm

CIRCLE 175 ON READER SERVICE CARD→

NEW PRODUCTS

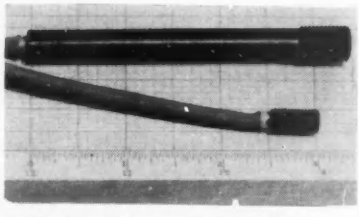
switches, analog-to-digital encoders, etc. Called the Dyna-Servo transducer, it features an electronic balancing system and can be used with a variety of sensing elements. In operation, motion of its sensing element positions the core of a differential transformer. Its balancing system uses an amplifier to operate a motor which provides the necessary output torque and, through a mechanical feedback arrangement, repositions the transformer coil to return the electronic system to balance. —The Bristol Co., Waterbury, Conn.

Circle No. 305 on reply card

BUILT-IN INVERTER

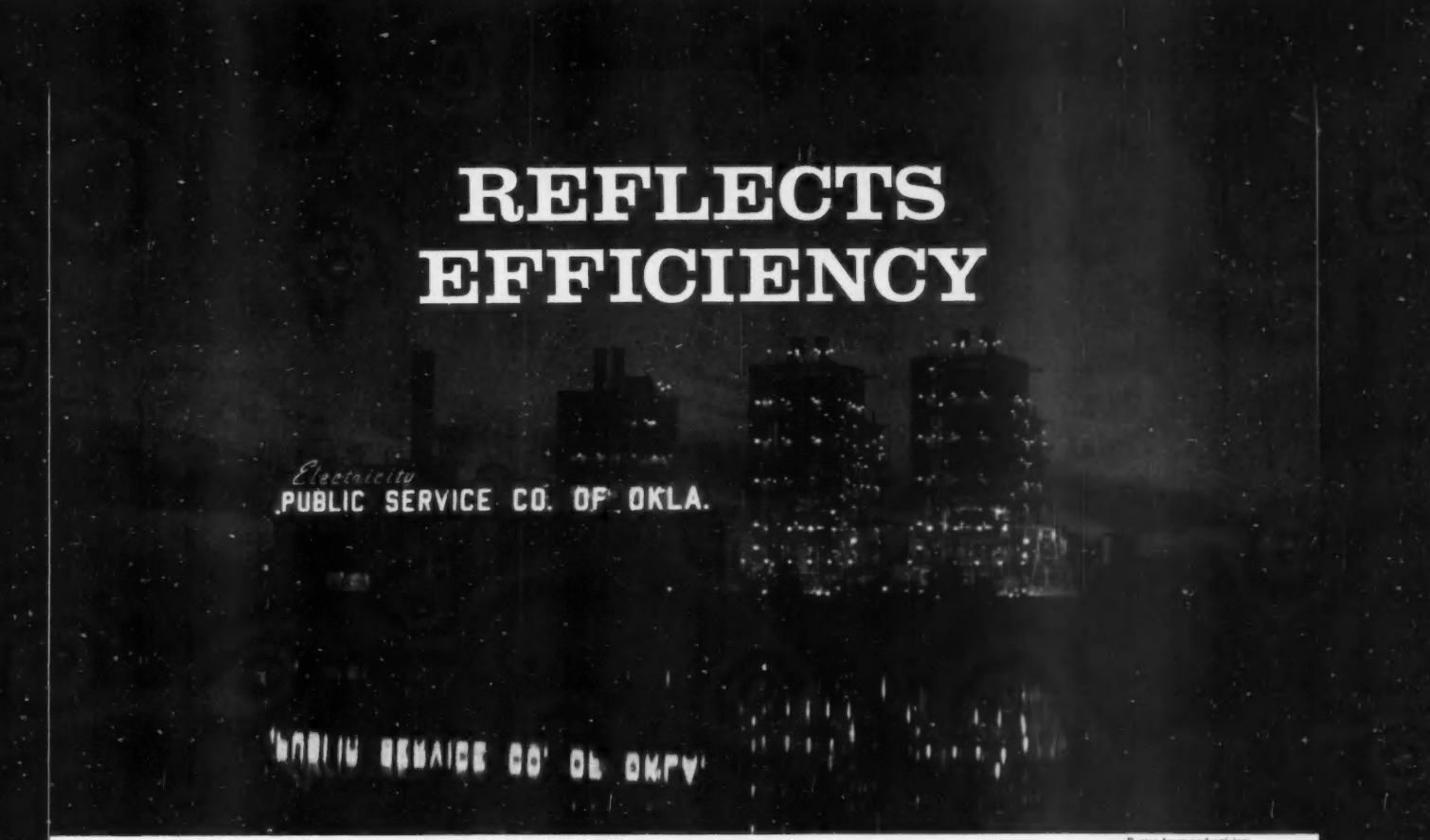
Rated performance for at least 1,000 hrs is guaranteed as the operating life of this new type of rate gyro. Basis for the unusually long life of this gyro is an inverter actually built into the package which permits the use of an ac spin motor. According to the manufacturer, the new unit requires no more space and actually weighs less than standard gyros of similar capacity.—Gyro Dynamics Div., Darco Industries, Inc., Manhattan Beach, Calif.

Circle No. 306 on reply card



FOR IN-WALL LOCATIONS

Called a Delta-Couple, this new temperature sensor permits accurate temperature measurements with a minimum of thermal disturbance at precise in-wall locations of steel structures having a section thickness of ¼ in. or more. Chromel-alumel is offered as the standard junction material, while a variety of body materials is available. Leads are 10-in. long No. 28 B&S,



Burton browne advertising

because PANALARM REDUCES LOGGING TIME TO SECONDS...CURTAILS COSTLY OUTAGES

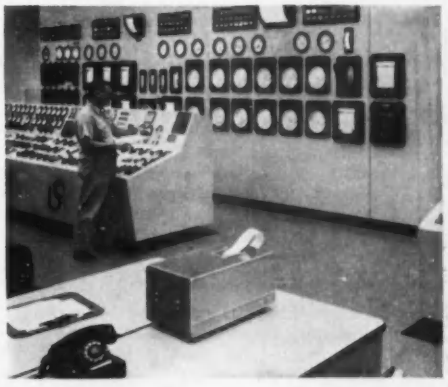
Public Service Co. of Oklahoma reports greater continuity of service and fewer costly outages from using PANALARM Annunciators in its new Tulsa station

PANALARM "flashing-ringback sequence" Recording Annunciator System converts raw data into usable information in seconds—a tremendous improvement over slow, old fashioned manual logging. Costly outages are fewer because of the speed and reliability with which off-normal conditions are registered.

The Recording Annunciator System sounds an alarm when trouble occurs. Simultaneously, it prints an accurate alpha-numeric digital record of the date and time of trouble and identifies the equipment that failed and/or returned to normal, eliminating possibility of operator error.

Another big advantage is that it continues receiving and recording information during emergencies, relieving the operator of this burden. The operator then concentrates his entire attention on ending the emergency. Later, a precise, sequential record is available for both operators and engineers to study as a basis for preventive maintenance and action.

For an optimum competitively priced Recording Annunciator System for your plant, talk to Panellit engineers.
Sales and engineering offices in all principal cities.



PANALARM ANNUNCIATORS record critical information on 7 turbine generators related to differential shutdown, overvoltage, ground detection, motor control, loss of field, pressures, temperatures, and shutdown or bus tie transfer operations.

For complete technical details on the Recording Annunciator, write for Bulletin 102A today.

PANALARM DIVISION OF PANELLIT, INC. PANELLIT

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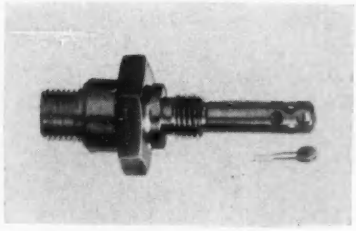
CIRCLE 177 ON READER SERVICE CARD

glass-asbestos insulated. Bodies feature a $\frac{3}{8}$-24 NF, Class 2 thread for installation. – Advanced Technology Laboratories, Mountain View, Calif.

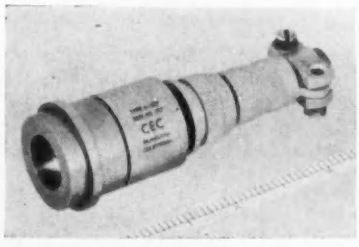
Circle No. 307 on reply card



USES PLATINUM FILM

Use of deposited platinum film as a sensing element in a new line of temperature probes not only cuts down on the size of probe required, but also improves base resistance, operational stability, and speed of response. More rugged than wire-wound transducers, these new units have an operating temperature range of from minus 453 to plus 800 deg F, and are suitable for liquid or gas applications.–Nacimco Products, San Diego, Calif.

Circle No. 308 on reply card



FLUSH-MOUNTED

Because this Type 4-327 unbonded strain gage pressure transducer uses a flush-mounted diaphragm, it can easily measure high frequency transient phenomena. Models are available in pressure ranges from 0-100 to 0-5,000 psi gage and absolute. Provision is made for adjustment of bridge balance, temperature compensation, and sensitivity external to its strain gage element.–Consodidated Electrodynamics Corp., Pasadena, Calif.

Circle No. 309 on reply card

RADIATION FUEL GAGE

A lightweight, transistorized radiation fuel gage developed for the Navy pro-

Key building block in flexible process control...
the Beckman 123 Data Processing System. ⌘ Use it alone for process data logging and alarming. Use it with a general-purpose computer for computer control. Its flexibility allows you to first study and then control your process...as well as modify process variables and easily reset controls. ⌘ In addition to this flexibility, the 123 Data Processing System offers all-transistorized circuits for maximum dependability... pinboard programming for ease of operation...100 or more channels to handle any logging problem...typewriter, paper tape, or punchcard readout... visual and audio alarms. ⌘ Let a Beckman stream-control specialist help you to a 1-2-3-4 building block solution to your process control needs... from sample handling (1) and stream analysis (2) through data processing (3) and digital computing (4) to an ultimate closed loop. For more information on the 123 Data Processing System or an on-stream survey, write for Data File 46-3-09.

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2500 Fullerton Road,
Fullerton, California

CIRCLE 179 ON READER SERVICE CARD

NEW PRODUCTS

vides an accurate means of measuring both solid and liquid propellants in missile and aircraft fuel tanks. According to the manufacturer, performance of the system is unaffected by impurities in the fuel, cosmic radiation, and changes in altitude. Flight attitude is said to have little effect on its accuracy. System consists of gamma sources, detectors, a power supply, and, for manned aircraft application, a cockpit indicator.—Atomics International, Div. of North American Aviation, Inc., Canoga Park, Calif.

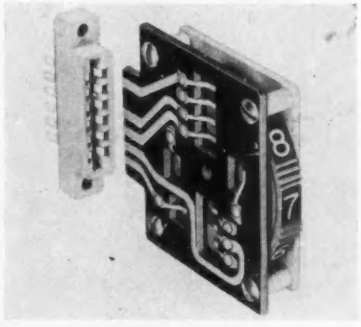
Circle No. 310 on reply card

PLUS. . . .

(311) **Columbia Research Labs,** Woodlyn, Pa., has announced a new line of true compression **miniature accelerometers** for use where size and weight are critical features. . . . (312) A new **shaft position digital encoder** with 13-bit binary output is now available from **ASCOP Div., Electro Mechanical Research, Inc.,** Princeton, N. J. . . . (313) Liquid and gas temperature measurements to 1,800 deg F and at pressures in excess of 2,000 psig can now be handled by a **thermocouple probe** available from **Technical Industries Corp.,** Pasadena, Calif.

Circle Nos. 311, 312, or 313 on reply card

CONTROLLERS, SWITCHES & RELAYS



THUMBWHEEL SWITCH

A new modular 10-position binary thumbwheel switch requires only ½ in. panel space and is available with either fixed or replaceable wafers. Removable-type switch is designed for use with

HIGH POWER IN SMALL PACKAGES

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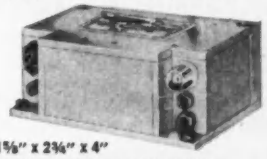
HIGH POWER IN SMALL PACKAGES

Unhampered by traditional thinking, TELECHROME engineers have developed an entirely new concept in telemetering equipment — unequalled in compactness, ruggedness and dependability.

TELEMETERING TRANSMITTERS FM/FM or PDM/FM Crystal Controlled 215 to 260 Megacycles

NEW! 1483A1 — 4 Watt FM Transmitter.



1⅝" x 2¾" x 4"
Features AFC for .005% stability

Model 1463 Transmitter.

5 1/32" x 3 3/16" x 4"
15 to 30 Watts

Model 1460-M RF Amplifier

3.37" x 3.25" x 2"
2 Watt input; 10-30 Watt output

Model 1466A-AF Amplifier

6.5" x 4" x 3.25" RF Amplifier
2 watts in — 100 watts out

Model 1462 Transmitter.

6" x 4¼" x 3¾"
50 to 80 Watts

800C — Sub-Carrier Oscillator

1.9" x 1.9" x 2.45"
Dev. Stab: ± 1% band width
Dev. Linearity: Less than 1% band width

Full Specifications & Details Available on Request

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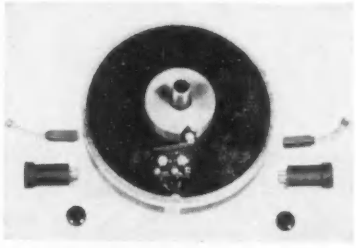
Lombard, Ill., MAyfair 7-6026

SOUTHWESTERN ENGINEERING DIVISION • 4207 Gaston Ave.
Dallas, Tex., TAylor 3-3291

CIRCLE 181 ON READER SERVICE CARD 181

fixed printed circuit receptacles. Fixed-type switch is designed with soldering terminals. Three- or four-bit binary and complementary outputs can be furnished. Modular construction permits horizontal or vertical stacking.—Chicago Dynamic Industries, Inc., Chicago, Ill.

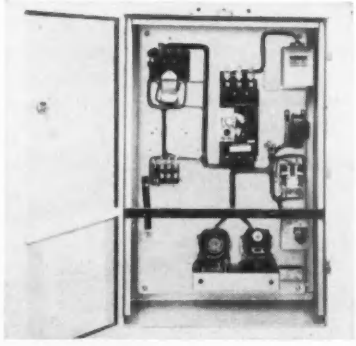
Circle No. 314 on reply card



SWITCH UPS RING LIFE

A new type of collector ring for opening a circuit in a particular shaft position uses a single miniature switch to eliminate the arcing and burning problems commonly encountered in rings using insulated inserts. Its design not only provides more efficient power interruption but also increases the life of the ring. Positioning can be controlled within 2 deg.—The B. A. Wesche Electric Co., Cincinnati, Ohio.

Circle No. 315 on reply card



PUMP CONTROL

Photo above shows a new three-phase, 60-cycle, 220/440-vac control package designed to automatically control and protect squirrel cage pump motors. Unit features a three-pole TC relay which provides positive protection against locked rotor, single-phase starting and running, and normal overload. System provides a definite time se-

quence restarting and a 15-min interval programming. – Westinghouse Electric Corp., Pittsburgh, Pa.

Circle No. 316 on reply card

RUGGED OPTICAL SWITCH

The LS series single lens optical switch, for photoelectric control applications, consisist of a light source, photocell, and transistorized amplifier in a single cast aluminum enclosure. Only external element required is a patented reflector which returns the light beam to the source despite misalignments in excess of 15 deg. A half-silvered mirror, between light source and lens, directs the reflected light beam to the photocell. Focused and parallel beams are available for operating ranges of from 1 in. to 80 ft. Insensitive to ambient light, shock, and vibration, the unit sells for $136.50.– Presin Co., Santa Monica, Calif.

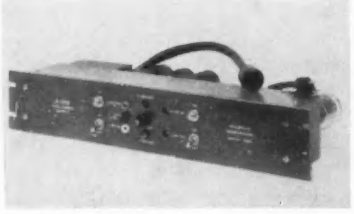
Circle No. 317 on reply card

PLUS. . . .

(318) A new **proximity switch,** consisting of a sensor and a separate transistorized amplifier with plug-in relay and designed for use in unfavorable enviroments, was recently introduced by **Micro Switch Div., Minneapolis-Honeywell Regulator Co.,** Freeport, Ill. . . . (319) A small, lightweight **rotary switch,** manufactured by **Genge Industries,** Glendale, Calif., makes up to 100,000 contacts per min without bounce. . . . (320) The STR series **time delay relays,** offered by **Curtiss-Wright Corp.,** Wood-Ridge, N. J., features isolated switching contacts, voltage and temperature compensation, and instantaneous recycling.

Circle Nos. 318, 319, or 320 on reply card

POWER SUPPLIES

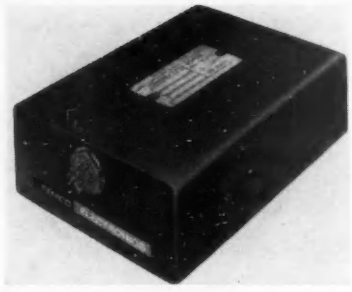


LOW RIPPLE

Photo above shows the Model R-100B, one of three new high performance regulated dc power supplies. These units have tracking dual outputs of plus or minus 300 volts at 500, 300,

or 100 ma. Their output impedance at dc is said to be lower by an order of magnitude than 1 ft of No. 14 wire. Other features include low power dissipation and an output ripple of about 200 μvac. Although designed specifically for analog computer applications, it could also be used in laboratory and industrial equipment.—G. A. Philbrick Researches, Inc., Boston, Mass.

Circle No. 321 on reply card



SUPPLIES RATE GYROS

Occupying just 20 cu in., this new single phase inverter will supply up to 20 watts of 26-volt, 400-cycle power for rate gyro packages. For a 24-32-vdc input, its output voltage will be within 1 percent and its output frequency within 0.4 cps. Unit meets or exceeds all applicable portions of MIL-E-5272 and has a full load efficiency of more than 60 percent.—Temco Aircraft Corp., Dallas, Texas.

Circle No. 322 on reply card

RELIABLE DC SOURCE

A line of fail-safe power supplies called Cadpacs operates from ac power and replaces binary-type dry cell batteries for dc power. Units are designed for use where the dc output must be sustained if and when the ac input is

COMPACT, RELIABLE, VERSATILE . . .

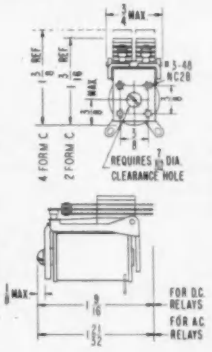
this is P&B's miniature MH relay

The MH is not a new relay.

As a matter of fact, we've been building and selling this series for seven or eight years. Its reliability and exceptional longevity have been proved in business machines, airborne computers and a host of other products.

Engineers like its fast action, its small size, its light weight. They like the wide selection of contact forms . . . up to 18 springs (9 per stack, DC) as well as the fact MH relays can be furnished to switch loads ranging from dry circuit to over 5 amps at 115 volts, 60 cycle resistive.

A multiple choice of terminations add to the MH's versatility. This relay, for example, can be adapted for printed circuits, furnished with taper tabs or a long list of other terminals. Get all the facts by calling your nearest P&B sales engineer today.



MH ENGINEERING DATA

GENERAL:

Breakdown Voltage: 500 volts RMS between all elements.

Ambient Temperatures: −45° C to +85° C. (−65° C to +125° C on special order.)

Shock: 30g on special order.

Vibration: 10g from 55 to 500 cps.; .065" max. excursions from 10 to 55 cps. on special order.

Weight: 2½ ozs. max. (open relay)

Terminals: Pierced solder lugs; special lugs for printed circuits, taper tab (AMP #78).

CONTACTS:

Arrangements: Up to 9 springs per stack.

Material: ⅛" silver standard: Palladium or gold alloy also available.

Load: Dry circuits to 5 amps @ 115V AC res.

COILS:

Resistance: 22,000 ohms max.

Power: 100 mw per movable min. to 4 watts at 25° C max. (200 mw min. to meet max. shock/vibration spec.)

Duty: DC: Continuous. AC: Intermittent (Two pole relay max.) open. Sealed units supplied with full wave rectifier inside can.

Voltages: DC: Up to 110 volts. AC: Up to 230 volts 60 cycles.

The relays below are variations of the MH relay structure.

MA LATCHING
Electrical latch, mechanical reset. Small, versatile and offered with selection of contact arrangements.

MB CONTACTOR
Contacts rated 60 amp. 28 volts DC non-inductive. Will carry 150 amp. surge for a duration of 0.3 seconds.

MH SEAL-TEMP
Features sealed coil to minimize contact contamination. Available as hermetically sealed relay only.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

CIRCLE 185 ON READER SERVICE CARD

interrupted and also for low-voltage high-capacity dc reference voltage applications. Model shown here has a 6.0-vdc output and a total capacity of 450 ma-hr at a 10-hr rate without the ac input. Unit, including cells, weighs 18 oz and is approximately the size of an ac outlet cover.—American-Monarch Corp., Minneapolis, Minn.

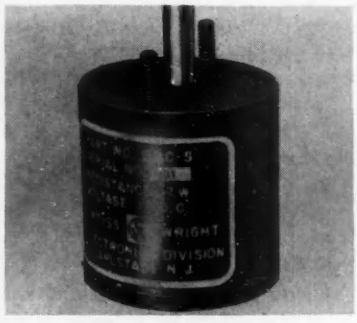
Circle No. 323 on reply card

PLUS. . . .

(324) **Power Sources, Inc.**, Burlington, Mass., recently announced a new heavy duty **transistorized power supply** for operation in the 200-250-vdc output range. . . . (325) The UVS-100 Bantom, a compact **voltage regulated supply** designed by **Matthew Labs.**, New York City, provides 4 to 36 vdc at 50 ma for powering solid state equipment. . . . (326) **Cook Batteries Subsidiary of Telecomputing Corp.**, Denver, Colo., offer a new automatically activated **silver-zinc battery** that provides one ampere-hour at 28-volts for missile applications.

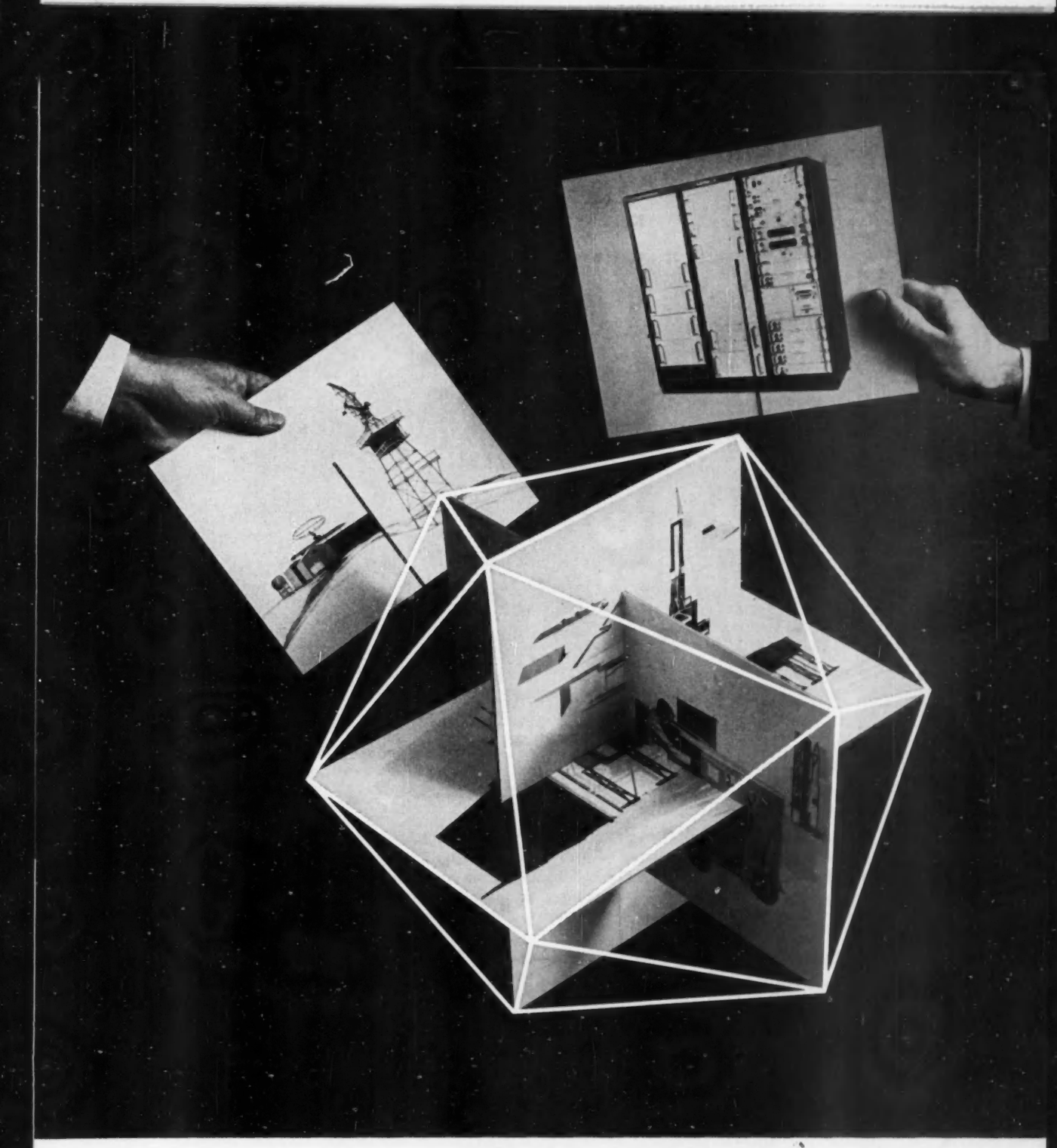
Circle Nos. 324, 325, or 326 on reply card

ACTUATORS & FINAL CONTROL ELEMENTS



HIGHLY RELIABLE

Designed to meet the requirements of both military and commercial applications, this new rotary solenoid features an inherently balanced construction and high resistance to severe shock or vibration. Its spring-returned armature rotates between two field coils; there's no axial movement of the shaft and no detent mechanism. Limit stops insure a constant angular displacement



The Matrix of Site Instrumentation

Site instrumentation—from complete electronic installation management to the engineering of customized systems and sub-systems—is a specialty of Western Design. ■ Typical of Western Design's site instrumentation capability is the new data calibration system for the Air Force Minuteman ICBM, designed to certify performance of transducers in the Hercules solid propulsion system. This automatic system, with both permanent and quick-look read-out, measures 160 transducers in 10 minutes, incorporates high safety standards and can be operated remotely by unskilled personnel. ■ For reliable, imaginative site instrumentation, check Western Design . . . a company with strong corporate financial back-up and extensive experience in military electronic and electro-mechanical equipment, sub-systems and systems. For further information, write for Data File CE-1029-1.

Western Design

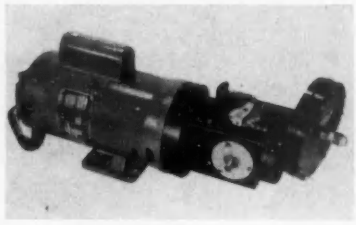
DIVISION OF U.S. INDUSTRIES, INC.

SANTA BARBARA AIRPORT, GOLETA, CALIFORNIA

NEW PRODUCTS

each time the field coils are energized. Standard angular movement is 35 deg. Either clockwise or counterclockwise rotation may be specified.—Curtiss-Wright Corp., Wood-Ridge, N. J.

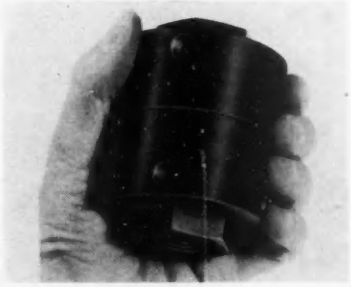
Circle No. 327 on reply card



AIR CONTROLLED

Fitted with a diaphragm for vacuum or pressure control, this new Servotran variable speed drive is designed for process control applications requiring pneumatic to mechanical conversion. Maker claims that an input pressure range of approximately 0-10 in. of water suffices to control the entire output range from full speed forward to full speed reverse. Models are available in a variety of speed and power ranges. —Humphrey, Inc., San Diego, Calif.

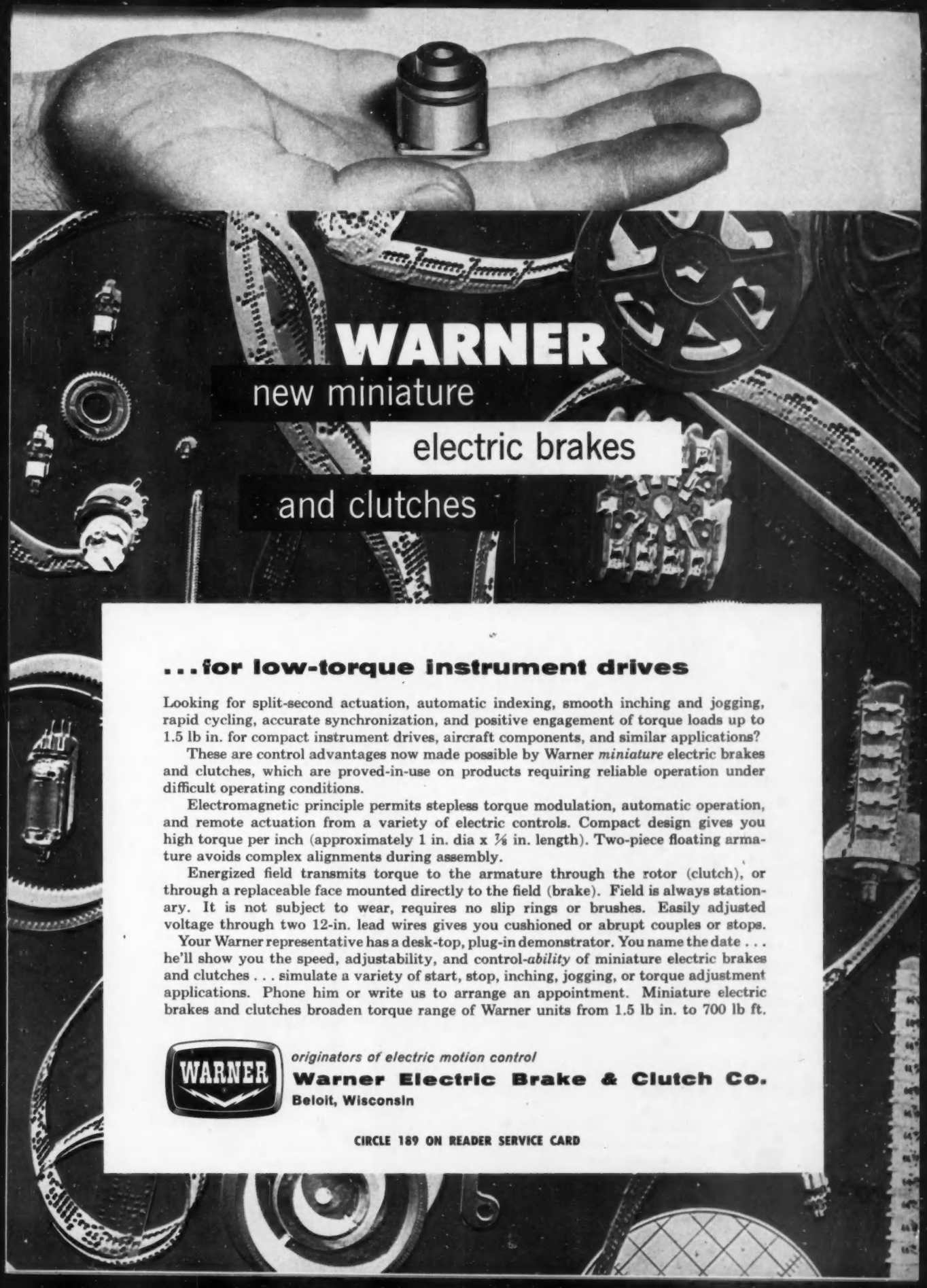
Circle No. 328 on reply card



IN-LINE VALVE

Featuring an above-normal flow coefficient of 7.5, this compact, ½-in., in-line valve was rated for a maximum pressure of 300 psi at 180 deg F. It measures 2¾ in. in diameter and has an overall length of 3½ in. Simple field operations permit rapid switching from normally-open to normally-closed operations as well as rapid changes in flow direction. Units are available in any stock material; bronze sleeve and bridge, stainless steel plugs, and neoprene O-rings are standard.—G. W. Dahl Co., Inc., Bristol, R. I.

Circle No. 329 on reply card



...for low-torque instrument drives

Looking for split-second actuation, automatic indexing, smooth inching and jogging, rapid cycling, accurate synchronization, and positive engagement of torque loads up to 1.5 lb in. for compact instrument drives, aircraft components, and similar applications?

These are control advantages now made possible by Warner *miniature* electric brakes and clutches, which are proved-in-use on products requiring reliable operation under difficult operating conditions.

Electromagnetic principle permits stepless torque modulation, automatic operation, and remote actuation from a variety of electric controls. Compact design gives you high torque per inch (approximately 1 in. dia x ⅜ in. length). Two-piece floating armature avoids complex alignments during assembly.

Energized field transmits torque to the armature through the rotor (clutch), or through a replaceable face mounted directly to the field (brake). Field is always stationary. It is not subject to wear, requires no slip rings or brushes. Easily adjusted voltage through two 12-in. lead wires gives you cushioned or abrupt couples or stops.

Your Warner representative has a desk-top, plug-in demonstrator. You name the date . . . he'll show you the speed, adjustability, and control-*ability* of miniature electric brakes and clutches . . . simulate a variety of start, stop, inching, jogging, or torque adjustment applications. Phone him or write us to arrange an appointment. Miniature electric brakes and clutches broaden torque range of Warner units from 1.5 lb in. to 700 lb ft.

WARNER

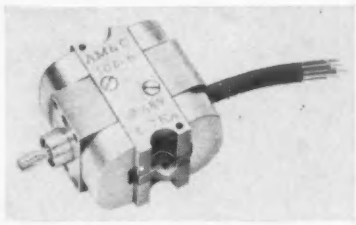
originators of electric motion control

Warner Electric Brake & Clutch Co.

Beloit, Wisconsin

CIRCLE 189 ON READER SERVICE CARD

NEW PRODUCTS



WITH ROTARY OUTPUT

Output of this miniature, high performance torque motor is in the form of a shaft rotation, free from backlash, end play, and radial play. Device provides an actual shaft rotation of up to 12 milliradians in either direction. Pressure-proof O-ring seal may be used on the output shaft to isolate the motor from the controlled medium.—American Measurement & Control, Inc., Waltham, Mass.

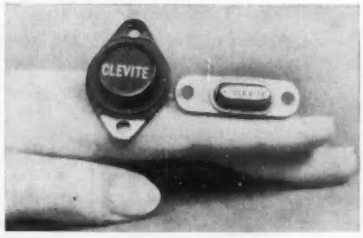
Circle No. 330 on reply card

PLUS. . . .

(331) **Guidance Controls Corp.**, Hicksville, N. Y., now offers a line of subminiature **clutches and brakes** which feature zero backlash, zero end play, and no slip rings. . . . (332) **A linear-magnetic actuator** which operates without rectification from a 400-cycle power source is now available from **B. H. Hadley, Inc.**, Los Angeles, Calif. . . . (333) **General Controls Co.**, Burbank, Calif., has introduced a line of motor operated **rotary plug valves** designed with a high G-factor for jet aircraft applications.

Circle Nos. 331, 332, or 333 on reply card

COMPONENT PARTS



SMALLER AND LIGHTER

Photo above compares one of the new Spacesaver power transistors with a standard size unit. Half the size and

BASIC BUILDING BLOCKS FROM KEARFOTT

DIRECTIONAL GYRO

This compact new gyro, designed for application in high-performance aircraft and missiles, provides extremely accurate attitude data. Its liquid bubble-type vertical sensing element generates error signals proportional to spin axis displacement from horizontal, while minor wiring modifications permit sensor connection to leveling torquer, completing inner axis leveling loop.

TYPICAL CHARACTERISTICS #A2215

Environmental Capabilities
- Vibration: 5g, 20-1000 cps; 10g, 1000-2000 cps
- Temperature Range (operative): —54°C to +71°C
- (non-operative): —65°C to +85°C
- Altitude: Unlimited

Azimuth Pickoff
- Excitation: 26V, 400 cps, single phase
- Output (sinusoidal): 11.8V ± 5% max.
- Error from E.Z.: 10 min. max.

Motor
- Excitation: 115V, 400 cps, three phase
- Speed: 23,500 RPM
- Power: Starting: 35 watts; Running: 7.5 watts

Performance Characteristics
- Drift: 4°/hr. max.
- Leveling Rate: Between 2° and 4°/min.
- Azimuth Torquing Rate: 360°/min. (intermittent) 40°/min. (continuous)

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT

VERTICAL GYRO

Kearfott's rugged new vertical gyro, designed for missile application, is a two-degree-of-freedom instrument with 360° of freedom about inner gimbal axis. Self-contained vertical erection system incorporates liquid bubble-type vertical sensing device.

TYPICAL CHARACTERISTICS #B2115

Environmental Capabilities
- Vibration: 5 g, 20-1000 cps; 10 g, 1000-2000 cps
- Temperature Range (operative): —54°C to +71°C
- (non-operative): —65°C to +85°C
- Altitude: Unlimited

Pickoffs
- Excitation: 26V, 400 cps, single phase
- Error from E.Z.: 10 min. max.
- Output Voltage (line to line): 11.8V ± 5% max.

Motor
- Excitation: 115V, 400 cps, three phase
- Power: Starting: 35 watts; Running: 7.5 watts

Performance Characteristics
- Repeatability of Established Vertical: To within a cone of half angle equal to 12 minutes of arc
- Scorsby Drift Rate in 5 Min. Time: 0.3°/min. (average)
- Erection Rate: Normal: Between 2° and 4°/min. Fast: 80°/min. intermittent, 40°/min. continuous

Physical Features
- Anisoelastic Drift: 0.08°/min/g² at resonance
- Weight: 5.5 lbs. (approx.)
- Mass Unbalance: 0.1°/min/g

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT

FREE GYRO

A highly reliable, two-degree-of-freedom instrument utilizing AC synchro transmitters at each gimbal axis. Designed to operate under the most severe missile conditions, this gyro has AC torquers mounted at each gimbal axis to permit command positioning or slaving of spin axis to desired reference position; each torquer capable of producing a precession rate of 360°/minute with 12.5 watts/phase power input.

TYPICAL CHARACTERISTICS #G2315

Environmental Capabilities
- Temperature Range: (operative): —54°C to +71°C (non-operative): —65°C to +85°C
- Altitude: Unlimited
- Vibration: 10g, 10-2000cps

Pickoffs
- Excitation: 26V, 400 cps, single phase
- Output (sinusoidal): 11.8V ± 5% max.
- Error from E.Z.: 10 min. max.

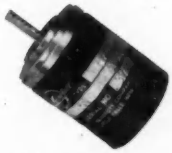
Motor
- Excitation: 115V, 400 cps, three phase
- Speed: 23,500 RPM
- Momentum: 2.25 x 10^6 gm cm²/sec

Caging and Preset Provision (Electrically energized torquer type)
- Excitation: 115V max./phase
- Torquer Constant: 22.8 dyne cm/Volt²

Performance Characteristics
- Free Drift: 5°/minute each axis
- Runup Time: 1 minute max.
- Torquing Rate: 360°/min. (intermittent) 40°/min. (continuous)

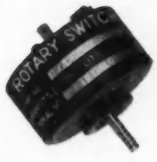
Write for complete data.

Synchronous Motor



Ferrites

Rotary Switch



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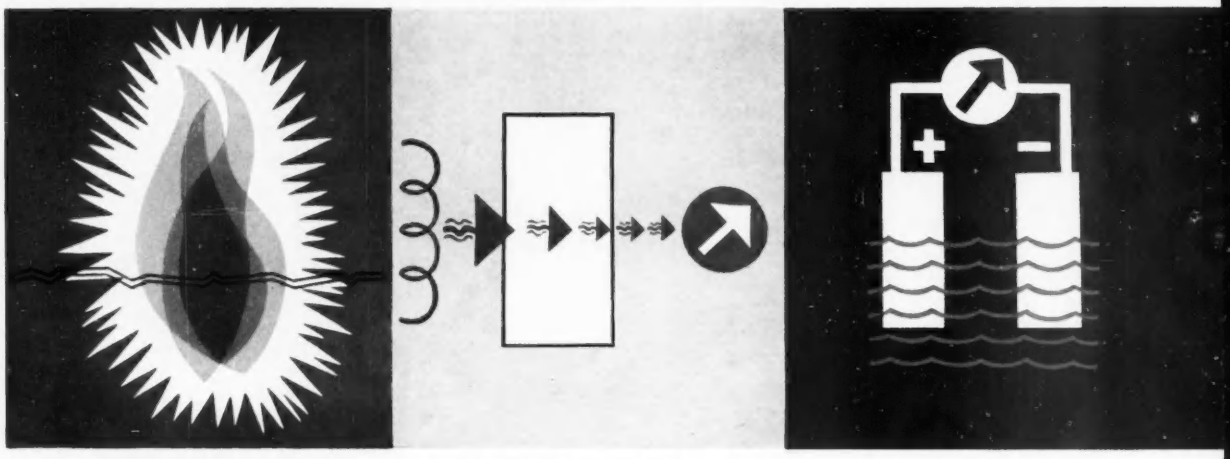
CIRCLE 191 ON READER SERVICE CARD 191

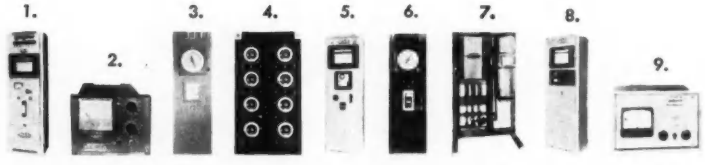
MSA Instruments apply all these principles



Catalytic Combustion **Infrared Analysis** **Depolarization**

MSA

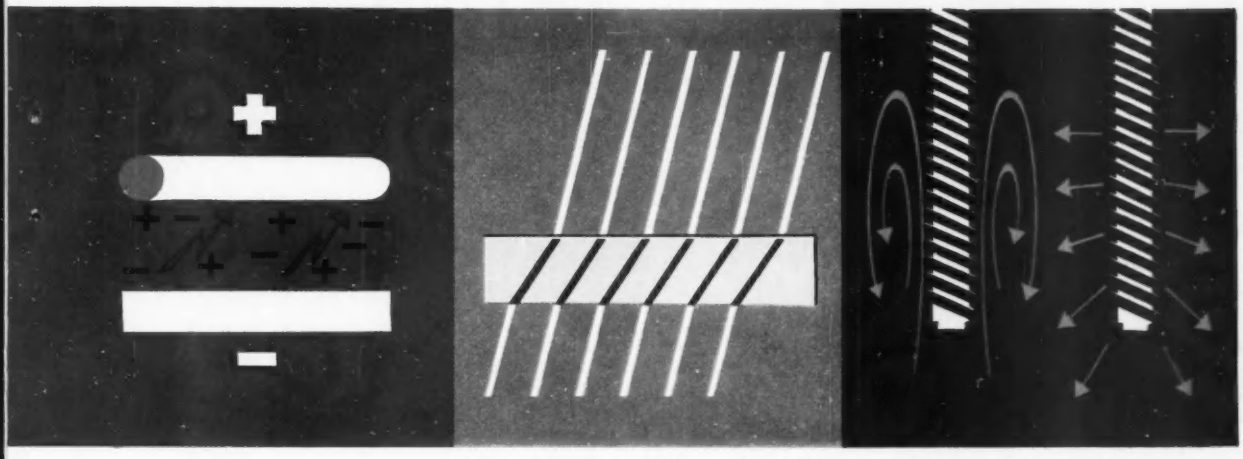
INSTRUMENT DIVISION
Mine Safety Appliances Company
Pittsburgh 8, Pennsylvania



1. M-S-A® LIRA® Infrared Analyzer Model 200 **2.** M-S-A® LIRA® Infrared Analyzer Model 300 **3.** M-S-A® Inert Gas Analyzer **4.** M-S-A® Combustible Gas Analyzer **5.** M-S-A® Thermatron Analyzer **6.** M-S-A® Oxygen Indicator **7.** M-S-A® Water Vapor Recorder **8.** M-S-A® BillionAire® Analyzer **9.** M-S-A® Process Refractometer

®Trademark

for dependable process stream analysis



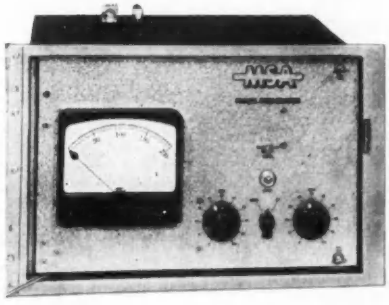
Ionization

Refraction: Now MSA packages the principle of light refraction for continuous measurement of organic and inorganic liquids.

The new M-S-A® Process Refractometer shown below, compares the refractive index of a stream with a constant standard. Controls quality in either stream or batch processes. Converts to new problems quickly and easily.

MSA has been supplying industry with similar "brains" for gas analysis since 1922. So, we're not newcomers. Our people are competent professionals. And so are our instruments. Both are extremely articulate when it comes to process stream analysis.

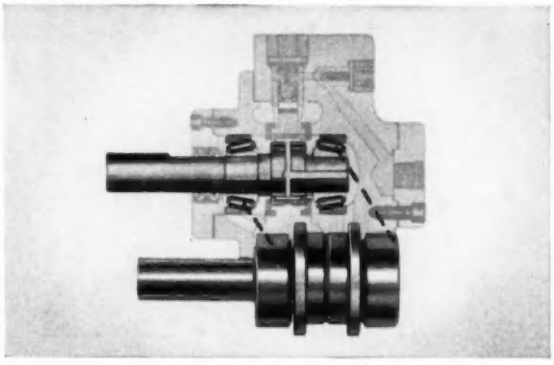
There are many MSA approaches to measuring gas concentrations. From the simplest to the most sophisticated. Most of these approaches stem from the principles symbolized above. Write us for instrument literature on the new M-S-A Process Refractometer or any of our other process stream analyzers.



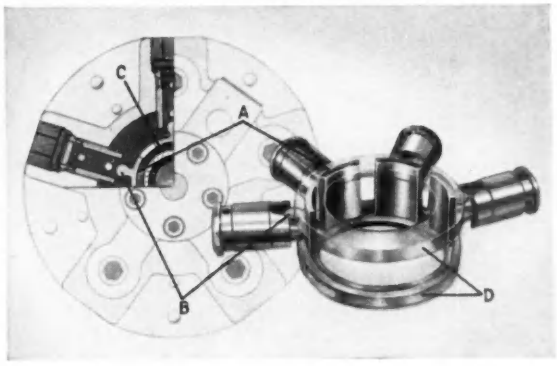
Thermal Properties

FOR HEAVY-DUTY PERFORMANCE AT PRESSURES TO 5,000 PSI . . .

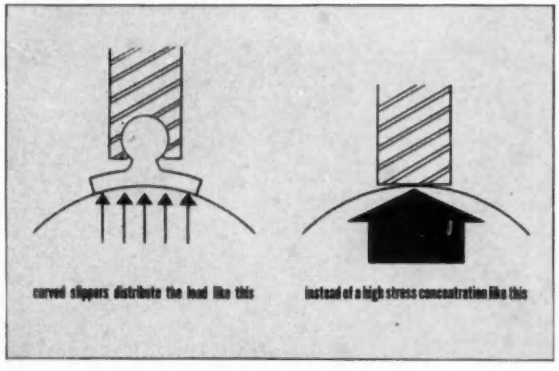
Only one hydraulic pump offers these 4 benefits . . . AE Hydramite®



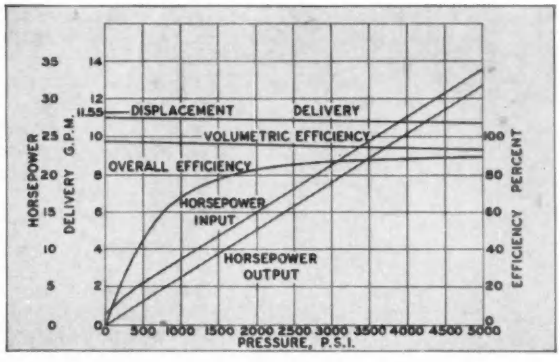
1. Tapered roller bearings. Two high-capacity, heavy-duty tapered roller bearings support the eccentric cam shaft. This means that a Hydramite can take more punishment . . . handle heavier unbalanced loads . . . and last longer. The pump casing is ported so that the pumping action of tapered bearings will provide better lubrication.



2. Positive pumping action. No cam follower springs to fail. Each plunger connects to a curved slipper (A) through a knuckle joint (B). In succession, plungers are pushed out by the cam shaft roller bearing (C) and pulled back by return rings (D) which hold each slipper snugly against outer race of the cam bearing.



3. Curved Slipper distributes thrust load of its plunger and reduces unit stress to the point where maintenance is never required at what is a critical wear spot in most hydraulic pumps. Also, curved slippers riding on the outer race of the cam shaft roller bearing minimize scrubbing action between these parts.



4. High efficiency. With a Hydramite you get an overall efficiency of 85%. Shown above is typical 10 gpm pump curve. Its flat overall high efficiency has little variation between 1,500 and 5,000 psi. What's more, with a Hydramite you get positive suction. There is no need for supercharging equipment which reduces system efficiency.

To meet your specific requirements, Hydramite pumps can be supplied for constant displacement from 3 to 25 gpm at 5,000 psi and 60 to 100 gpm at 3,000 psi for hydraulic fluids with viscosities of 150 to 300 ssu at 100° F. In special applications they have handled viscosities as low as 40 and as high as 900 ssu at 100° F. Special materials and seals permit handling of missile fuels and special fluids at higher temperatures. Available in flange, foot or face mounted styles.

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3	13	23	33	43	53	63	73	83	93	103	113	123	133	143	153	163	173	183	193
4	14	24	34	44	54	64	74	84	94	104	114	124	134	144	154	164	174	184	194
5	15	25	35	45	55	65	75	85	95	105	115	125	135	145	155	165	175	185	195
6	16	26	36	46	56	66	76	86	96	106	116	126	136	146	156	166	176	186	196
7	17	27	37	47	57	67	77	87	97	107	117	127	137	147	157	167	177	187	197
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9	19	29	39	49	59	69	79	89	99	109	119	129	139	149	159	169	179	189	199
200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390
201	211	221	231	241	251	261	271	281	291	301	311	321	331	341	351	361	371	381	391
202	212	222	232	242	252	262	272	282	292	302	312	322	332	342	352	362	372	382	392
203	213	223	233	243	253	263	273	283	293	303	313	323	333	343	353	363	373	383	393
204	214	224	234	244	254	264	274	284	294	304	314	324	334	344	354	364	374	384	394
205	215	225	235	245	255	265	275	285	295	305	315	325	335	345	355	365	375	385	395
206	216	226	236	246	256	266	276	286	296	306	316	326	336	346	356	366	376	386	396
207	217	227	237	247	257	267	277	287	297	307	317	327	337	347	357	367	377	387	397
208	218	228	238	248	258	268	278	288	298	308	318	328	338	348	358	368	378	388	398
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2	12	22	32	42	52	62	72	82	92	102	112	122	132	142	152	162	172	182	192
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4	14	24	34	44	54	64	74	84	94	104	114	124	134	144	154	164	174	184	194
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6	16	26	36	46	56	66	76	86	96	106	116	126	136	146	156	166	176	186	196
7	17	27	37	47	57	67	77	87	97	107	117	127	137	147	157	167	177	187	197
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202	212	222	232	242	252	262	272	282	292	302	312	322	332	342	352	362	372	382	392
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205	215	225	235	245	255	265	275	285	295	305	315	325	335	345	355	365	375	385	395
206	216	226	236	246	256	266	276	286	296	306	316	326	336	346	356	366	376	386	396
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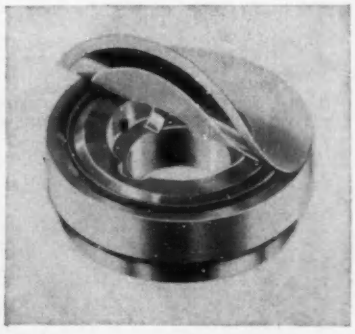
CIRCLE 197 ON READER SERVICE CARD

NEW PRODUCTS

weight of their present-day equivalent, these new components are now available in eight 3-amp switching types with breakdown voltages of 40, 60, 80, 100; dc gain ranges of 30-75 and 60-150; and frequency responses of 20 and 15 kc. Leakage current is 10 ma at 90 deg C.—Clevite Transistor Products, Waltham, Mass.

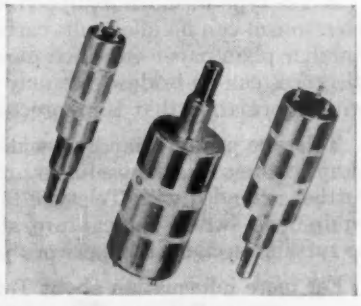
Circle No. 334 on reply card



SETS LIFE RECORD

Stringent tests of this new Rotoflex wire-wound potentiometer have shown that its life will exceed 85 million cycles at 500 rpm, with no change in total resistance, no significant change in linearity, and no appreciable signs of wear. Noise throughout the tests was less than 50 ohms. The device uses a patented capsule contact design in which a rolling pressure piece dimples a layer of gold foil into contact with the resistance element, thereby eliminating the wear problem associated with sliding contacts. Sealing of the unit eliminates dust and dirt problems.—Technology Instrument Corp., Acton, Mass.

Circle No. 335 on reply card



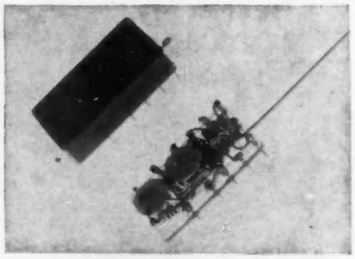
MEETS MOST SPECS

Designated Types 5000, 7500, and 1000, this matched series of precision

NEW PRODUCTS

multiturn potentiometers covers resistance values from 50 to 350 k and linearities up to within 0.075 percent. Common features include nickel-plated brass housings, molded terminal headers, and O-ring seals.–International Resistance Co., Philadelphia, Pa.

Circle No. 336 on reply card



LOGIC MODULES

The modular circuit shown here before and after encapsulation is part of a new integrated line of potted logic elements for 100-kc operation. Applications include portable, mobile, and airborne equipment. Reliability of the modules has already been proved in production missile applications.–C & K Components, Inc., Newton, Mass.

Circle No. 337 on reply card

SWITCHING TRANSISTOR

Ideal for power switching and power control circuits, the military type 2N1011 germanium PNP power transistor meets Signal Corps specifications NIL-T-10500/67 and will readily dissipate 35 watts at a mounting base temperature of 25 deg C.

Characteristics:

Maximum current rating: 5 amps
Current gain range: 30-75
Maximum collector-base voltage: 80 v
–Red Bank Div., Bendix Aviation Corp., Long Branch, N. J.

Circle No. 338 on reply card

PLUS . . .

(339) **John Oster Mfg. Co.**, Racine, Wis., offers a new prepackaged **module of Size 8 components** consisting of motor generator, gear train, synchro, and potentiometer. . . . (340) A Series 4 Vernistat precision **ac potentiometer** with a Size 9 front end mounting is now available from the **Vernistat Div., Perkin-Elmer Corp.**, Norwalk, Conn.

Circle No. 339 or 340 on reply card

BULLETINS & CATALOGS

(350) TAPE SYSTEMS. Data Tape Div., Consolidated Electrodynamics Corp., Bulletin 1618, 4 pp. Describes CEC's 5-681 digital tape recorder/reproducer transport, which operates at speeds up to 30 in. per sec, and the 5-682, a high-speed transport offering speeds up to 150 in. per sec.

(351) PULSE CODE SYSTEM. The Vapor Recovery System Co. Bulletin CP3707, 12 pp. Reviews the features and advantages of a basic pulse code telemetering system and illustrates typical applications ranging in complexity from a local level indicating system to a completely automatic remote control system.

(352) TIME DELAY RELAYS. Tempo Instrument, Inc., Engineering Bulletin 5905, 8 pp. Contains complete technical data on this company's line of electronic time delay relays. Also includes a comprehensive description of circuit design and some useful application notes.

(353) TRANSMITTING ROTAMETERS. Schutte and Koerting Co. Bulletin 18M, 4 pp. Covers the operation, application, construction, and special features of the Model 58 Pneumatic Transmitter, a position-balance instrument for transmitting rotameter flow data to indicators, recorders, controllers, and integrators.

(354) SYNCHRO COMPONENTS. Induction Motors of California, Bulletin 204, 4 pp. Provides detailed specifications on a complete line of Size 8 synchro components manufactured in general accordance with MIL-S-20708, ARP-461, MIL-E-5272, and MIL-E-5400. Design options, mechanical characteristics are listed.

(355) RECORDERS/CONTROLLERS. Industrial Div., Minneapolis-Honeywell Regulator Co. Specification FS-301-8, 6 pp. Describes and illustrates Honeywell's ElectriK Tel-O-Set recorders and recording control stations. Illustrations include dimension drawings, installation drawings, and schematic of the pen-positioning and error servos used in these instruments.

(356) DIGITAL PRESSURE SYSTEM. Technical Industries Corp. Technical manual. Discusses the design and operation of TIC's Model 203A precision digital pressure measurement and control system. Includes a block diagram showing interconnection of the pressure transducer, power supply, preamp, and amplifier as well as a circuit diagram of the system's ac pressure servo input.

(357) AIRCRAFT POWER SUPPLIES. Southwestern Industrial Electronics Co. Bulletin, 2 pp. Lists pertinent specifications on two new transistorized power supplies designed for use in airborne communication and navigation receivers as replacements for 14- and 28-volt D-10A dynamotors.

(358) MOTOR CONTROL CATALOG. Furnas Electric Co. Catalog 5900, 72 pp. Provides a condensed but thorough listing of general motor control products. Special Quick-Selector charts for magnetic and manual starters give horsepower, motor speed, heater size, ampere ratings, enclosure choices, style numbers, and list prices.

(359) HYDROCARBON DETECTOR. Instruments Div., Perkin-Elmer Corp. Brochure, 8 pp. Presents useful technical

Bulletins & Catalogs

data on the operation and application of P-E's Model 213 hydrocarbon detector, a completely self-contained portable instrument for rapid measurement of total organically bonded carbons in atmosphere or gases. Two-color flow diagram illustrates its major components.

(360) HIGH PERFORMANCE RELAYS. Relay Div., Electronic Specialty Co. Specification sheets. Package contains 10 complete specification sheets on three basic types of high performance relays. Additional sheets describe relay numbering codes, alternate header types, and alternate mounting types.

(361) AUTOMATIC CHECKOUT GEAR. Equipment Div., Epsco, Inc. Brochure, 4 pp. Covers four new pieces of automatic checkout equipment: an rms-to-dc converter, a voltage-to-digital converter, a timer counter, and a digital printer.

(362) GAS ANALYZERS. Mine Safety Appliances Co. Bulletin 0700-2, 4 pp. Provides complete details on four gas analyzing instruments designed for use in the metals industry. Gives scale ranges and outlines typical applications.

(363) FOR THE UTILITIES. General Electric Co. Bulletin GEZ-2975, 12 pp. Serves as a utilities buyer's guide to all General Electric instruments available for generating plants, distribution areas, load-dispatching offices, and substations. Photos are grouped under these categories along with lists of typical applications. Convenient table provides numbers of the more detailed publications.

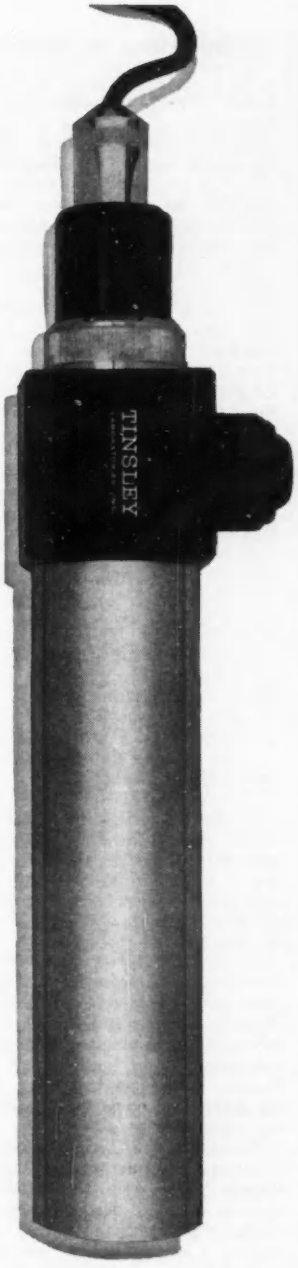
(364) VARIABLE DELIVERY PUMPS. Vickers, Inc. Bulletin A5233A, 6 pp. Uses two-color cutaway and exploded drawings to describe the operation and construction of this company's fixed angle variable delivery pump. Engineering data includes ratings, dimensions, and typical performance curves.

(365) AIR VALVE CATALOG. Industrial Products Div., Westinghouse Air Brake Co. Catalog A4-75.01, 16 pp. Lists almost 1200 different air directional valves for a wide variety of industrial applications. Also provides capacities, watts, dimensions, and JIC symbols for 55 operators and nine plastic valve types.

(366) PRECISE-POWER SYSTEMS. Electric Specialty Co. Bulletin 59-P, 32 pp. Jointly prepared with ESCO's affiliate, Regulators, Inc., this package actually contains eight bulletins ranging in size from 2 to 8 pages. These deal with a variety of rotary electromechanical power systems and components.

(367) STEPPER MOTORS. The A. W. Haydon Co. Technical Brochure SP9-1, 12 pp. Well illustrated brochure describes a new line of stepper motors and other pulsed stepping devices for driving potentiometers, coded discs, synchro transformers, and counting mechanisms. Illustrations include application schematics as well as pulse profiles.

(368) SPEED RECORDER. General Electric Co. Bulletin GET-2741-3A, 4 pp. Discusses application, features, operating principles, and specifications of General Electric's Type HF multirange strip-chart speed recorders. Industrial processing applications related to the paper, steel,

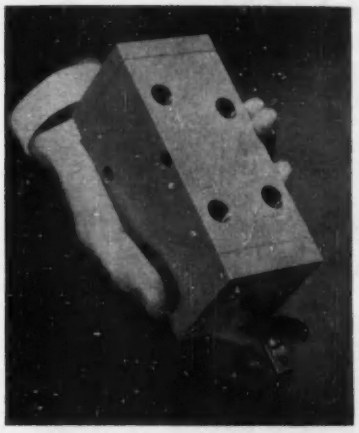


Why pay for an expensive alignment telescope when a Tinsley Autocollimator may meet your requirements for hundreds of dollars less? The Tinsley Autocollimator is easily capable of reading precise angles to ¼ minute accuracy. 20 power. Interchangeable light source and eyepiece for viewing from end or side. Fits standard fixtures. Economical and dependably accurate. Write for price and information.

TINSLEY
LABORATORIES, INC.
2526 Grove Street · Berkeley 4, California

CIRCLE 233 ON READER SERVICE CARD

Typical Control Functions solved by AIR CIRCUITRY



Westinghouse Multi-Position Cylinder

The Westinghouse Air Brake Company's complete line of AIR CIRCUITRY components contains a wide variety of pneumatic positioners to handle almost all of your force and positioning requirements.

No longer is pneumatic positioning limited to a single or double acting cylinder. Remotely controlled by directional and/or pressure control valves, both variable and fixed force and positioning is possible. Along with all the advantages of air, these devices are easily maintained and serviced. Uncomplicated and rugged, pneumatic positioners may be the answer to your control problems.

Typical Applications—The illustrated positioners have been used in almost every field of industry today. These positioners can:

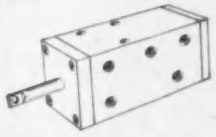
clamp	punch	snub	convey	push
rotate	lock	form	bend	blank
index	broach	crimp	cushion	pull
hold	squeeze	twist	stretch	eject
feed	shear	raise	brake	move
pierce	lower	press	turn	coin

If you have a positioning problem, let us know about it. It can probably be solved with AIR CIRCUITRY. For more information, ask for our catalog on Positioners.

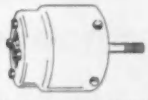
What is AIR CIRCUITRY?

This is the Westinghouse term for application of pneumatic control systems to industrial production operations. Safe, economical, precise AIR CIRCUITRY is now being used to solve the most rigorous and complex control problems in industry. Westinghouse Air Brake has pioneered the application and development of air control for more than 80 years. Today our engineers can design an air circuit which will help you boost production and cut costs in your plant or shop.

1. ONE AND TWO STATION POSITIONING—Single and double acting cylinders can perform all types of force and positioning functions. The Westinghouse line of cylinders includes diameters from 1" to 10"; strokes to suit application; single and double end; foot, swivel, flange and trunnion mounts.

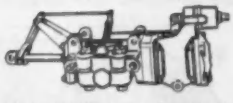


2. MULTI-STATION POSITIONING — Controlled by an associated directional valve, these cylinders attain 3, 4, 5 and 7 fixed positions of stroke. Three position cylinders are available in 2", 3", 4", 5" and 6" diameters. Strokes may be obtained to suit application.



3. VARIABLE FORCE AND POSITIONING — Diaphragm type cylinders are controlled by manually or mechanically operated pressure control valves to achieve a variable force or position of the rod. Various diaphragm areas and strokes available.

4. INFINITE POSITIONING-LIGHT—The actuator positioner has an infinite number of positions, governed by the amount of air pressure acting on its spring opposed diaphragm. Remotely operated pressure control valves dictate the position of the operated lever. This device has a low force rating.



5. INFINITE POSITIONING-HEAVY—The Westinghouse PNEUDYNE® Positioner can position accurately, independent of the opposing force, up to its power capacity. The power capacity is determined by piston size and supply pressure. Remotely controlled by pressure control valves, this device maintains its position throughout changes in the opposing force.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor

WESTINGHOUSE AIR BRAKE COMPANY
INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

CIRCLE 203 ON READER SERVICE CARD

Bulletins & Catalogs

textile, rubber, and other industries are described.

(369) MOTOR CONTROL CENTERS. Automatic Control Co. Bulletin SPM-1-1159, 16 pp. Features a variety of Autocon Plan-Pak motor control centers for industrial applications. Illustrates construction details and typical layouts and suggests a method for preparing both general and design specifications.

(370) METER-RELAYS. Assembly Products, Inc. Catalog, 12 pp. Presents a brand-new line of specialized expanded scale meter-relays with accuracies to within 0.5 percent. Includes dimensions, prices, and a complete description of both standard and special circuitry.

(371) MULTIVIBRATOR CIRCUITS. Shockley Transistor Corp. Application Data Bulletin, AD-6. Offers detailed information on the design and operation of high speed flip-flop and multivibrator circuits using four-layer diodes. Diagrams illustrate free-running, monostable, and bistable multivibrator circuits and a square wave generator.

(372) PNEUMATIC TIMER. Associated Control Equipment, Inc. Bulletin P-20, 2 pp. Photo and Block diagrams are used to illustrate the operation of the Servo-Gauge oscillator, a pneumatically operated timer adjustable from 0.3 to 60 complete cycles per min. Bulletin also lists typical applications and design data.

(373) CAPACITOR SPECS. International Electronic Industries, Inc. Bulletin 81558, 8 pp. Covers specifications and performance characteristics on a complete line of miniature and subminiature aluminum foil capacitors. Standard rating and selection charts are accompanied by notes on their use.

(374) COMPUTING SYSTEM. Royal McBee Corp. Bulletin S-482. Gives complete specifications on the new RPC-4000 electronic computing system, a fully transistorized, stored program, general purpose unit designed for both engineering and business data processing. Also discusses the features of some high speed peripheral equipment.

(375) ELECTRIC TRANSMISSION. Instrument Div., International Register Co. Bulletin NR-10, 4 pp. Illustrated brochure contains a detailed description of Acragage electric transmitters and receivers designed for use in remote pressure indication systems. Includes concise specifications and a cross-indexed table of materials and mounting types.

(376) CONTROL CATALOG. The Mercoid Corp. Catalog 860, 56 pp. Lists a wide variety of mercury switch devices for pressure, temperature, liquid level, and mechanical motion control applications. Also illustrates transformer-relays and a complete line of hermetically sealed mercury switches. Catalog is cross-indexed for easy reference.

(377) ELECTRONIC ENGINEERING. Airpax Electronics Inc. Airpax Technical Journal, Volume 1, No. 1, 4 pp. Available now for general distribution, this new periodical will be devoted to the study and theory of electronic components and systems. First issue features two articles, "The Dual [sic] Between Vacuum Tubes

and Magnetic Amplifiers" and "The Magnetic Amplifier as an Integrating Device".

(378) SPECIAL MATERIALS. Brooks Rotameter Co. Bulletin 150, 8 pp. Provides details on a number of alloys and plastic materials now used in the manufacture of rotameters for applications in corrosive environments. Bulletin also illustrates and describes a variety of meter designs which have been held tested.

(379) RESISTOR SELECTOR CHART. Weston Instruments Div., Daystrom, Inc. Form Z-44-A, 2 pp. Offered in the form of a durable loose-leaf insert, this handy selector chart eliminates the need for solving equations for power and Ohm's Law. Four values (current, voltage, power, and resistance) are arranged on four individual chart axes. With any two values known, a quick glance at the chart permits direct reading of the others.

(380) TAPE SEARCH EQUIPMENT. Remington Rand Div., Sperry Rand Corp. Booklet U-1729, 8 pp. Describes in detail the Univac Tape Searchwriter, an integrated system providing an economic means of searching a magnetic tape file and automatically typing desired information.

(381) POSITIONING CONTROLS. Jordan Controls, Inc. Bulletin J-105, 16 pp. Presents the company's complete line of linear and rotary actuators, valve operators, remote positioners, and a variety of systems for special positioning and program control applications.

(382) TENSION CONTROL. Bailey Meter Co. Performance report S11-1, 4 pp. Outlines design and operation of a strip tension control system used by a Pennsylvania steel mill to minimize breakage on three continuous annealing lines.

(383) POWER SUPPLIES. Electronic Measurements Co., Inc. Bulletin 422, 12 pp. Presents up-to-date coverage on a complete line of programmable, nonprogrammable, and general purpose power supplies. Also includes specifications on the new Regatron Mark II series of precision chopper stabilized calibrators.

(384) SOLENOID VALVES. Automatic Switch Co. Bulletin 506, 16 pp. Completely tabular, this selection guide and price list is said to cover the world's largest solenoid valve stock available for immediate delivery. Two-color sectional drawings and simple flow diagrams illustrate construction and operation.

(385) RELAYS PROTECTION. Presin Co. Brochure, 8 pp. Describes a line of potted RC networks, made by Rifa in Sweden, designed to provide an effective means of increasing relay contact life.

(386) REUSABLE BATTERIES. Yardney Electric Corp. Folder, 6 pp. Lists both electronic and physical characteristics as well as typical application data on a complete line of rechargeable Silvercel batteries. Seven performance curves illustrate discharge rates, discharge times, and ampere-hour outputs.

(387) PULSE TRANSFORMERS. PCA Electronics, Inc. Catalog, 18 pp. Covers history of low level pulse transformers, their chief differences compared to other transformer types, methods of measurement, and theory of application. Includes circuit diagrams, pulse width charts, specifications, and case types.

WHAT'S NEW

(Continued from page 48)

tionship to the other specialists.

As a result of these efforts, and of keeping a log on every machine, downtime on Milwaukee-Matics averages around 10 percent, and K&T strives to keep it lower. If you figure that Milwaukee-Matic replaces five standard machines, the downtime figure can be translated to around 2 percent, says Joerger. This is favorable with standard machines, "although Milwaukee-Matic saves so much money when it is operating that customers don't want to see it down at all if possible," he says.

Next step for K&T: A Model III Milwaukee-Matic which will be about twice the size of the current Model II (Model I was never built), with the same philosophy of operation.

—Stewart Ramsey
McGraw-Hill News

Warner & Swasey Buys Part of Wang Labs.

The Warner & Swasey Co., Cleveland machine tool builder, has acquired a substantial interest in Wang Laboratories, Inc., developer and builder of punched tape block readers and encoders, tape controlled point-to-point positioning systems, and other specialized devices.

The Labs were founded by Dr. An Wang, who in 1951 set up a research lab in Natick, Mass., which later progressed into the manufacture of equipment. Some of it is used on Warner & Swasey machine tools.

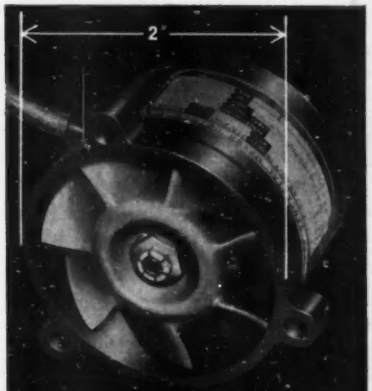
Gumpertz Warehouser Sold By Solartron John Brown

Industrial Electronic Engineers, Inc., North Hollywood, Calif., has signed an agreement with a new British company for use of its automatic order-filling equipment in a proposed automatic supermarket system.

Substantial overseas rights to the equipment, invented by Donald G. Gumpertz, president of IEE, have been granted to Solartron John Brown Automation Ltd., a company formed for the purpose of the venture by the Solartron Electronic Group Ltd., a top British electronics outfit, and the Scottish firm, John Brown Co., old line Clydebank shipbuilder.

Solartron is involved in still another business deal of some scope: it is being bought by Firth Cleveland, English holding and investment firm.

The Gumpertz machine is already in use in a California drug warehouse (see CtE, March '58, p. 20).



HIGH PERFORMANCE 2-Inch Cooling Fan

AiResearch Minifan* is an extremely high performance 400-cycle AC motor-driven fan used for cooling airborne or ground electronic and electrical equipment. Model shown has a flow capacity of 53.5 cfm at a pressure rise of 3.44 H_2O, and requires only 69 watts.

Minifan operates up to 125°C. ambient. Its size and weight make it ideal for spot cooling, cold plates or as a cooling package component. The fan can also be repaired, greatly increasing its service life.

Range of Specifications

- Volume flow: 21.5 to 53.5 cfm
- Pressure rise: .6 to 3.44 H_2O
- Speed: 10,500 to 22,500 rpm
- Single, two or three phase power
- Power: 16 to 69 watts
- Standard or high slip motors
- Weight: .36 to .48 lb.

A world leader in the design and manufacture of heat exchangers, fans and controls, AiResearch can assume complete cooling system responsibility. Your inquiries are invited.

*Minifan is an AiResearch trademark.

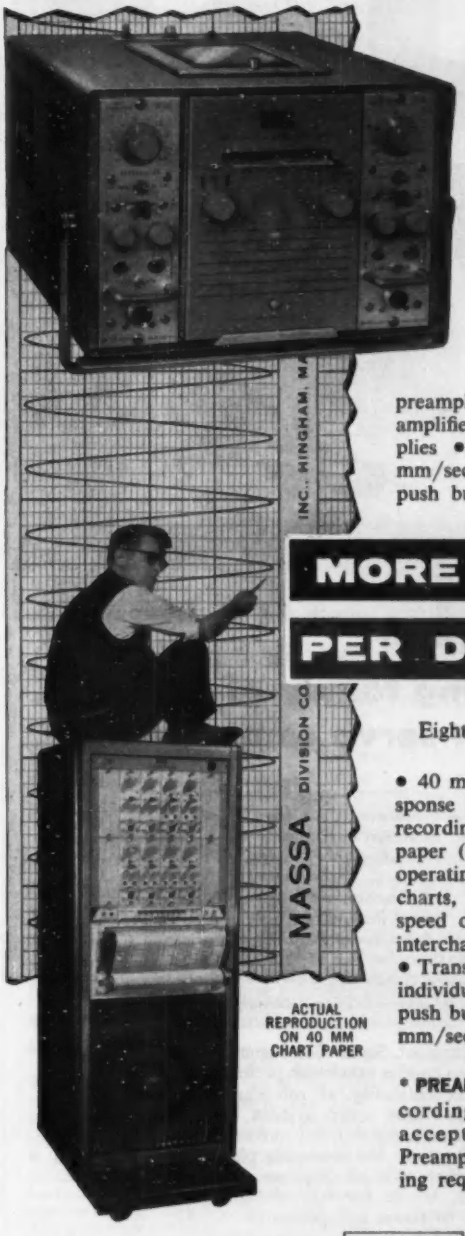
THE GARRETT CORPORATION

AiResearch Manufacturing Division

Los Angeles 45, California

CIRCLE 234 ON READER SERVICE CARD

MASSA *Announces* 40 MM AMPLITUDE *with* RECTILINEAR INK RECORDINGS



ACTUAL REPRODUCTION ON 40 MM CHART PAPER

Portable
two channel Meterite
Model BSA-250

• 40 mm amplitude • Frequency Response, DC to 120 cps • Rectilinear recordings on economical ink chart paper (save more than $3000 in 200 operating hours over other rectilinear charts, running at an average chart speed of 50 mm/sec.) • Choice of interchangeable plug-in preamplifiers* • Transistorized driver amplifiers with individual power supplies • 6 Chart speeds .5 to 200 mm/sec. • Event marker with internal push button control.

MORE DATA PER DOLLAR

Eight channel recording system,
Model BSA-850

• 40 mm amplitude • Frequency response DC to 120 cps • Rectilinear recordings on economical ink chart paper (save more than $6000 in 200 operating hours over other rectilinear charts, running at an average chart speed of 50 mm/sec.) • Choice of interchangeable plug-in preamplifiers* • Transistorized driver amplifiers with individual power supplies • 18 speeds push button controls .5 cm/hr to 200 mm/sec.

* **PREAMPLIFIERS** — All Massa Recording Systems are designed to accept a wide choice of plug-in Preamplifiers to satisfy every recording requirement.

Other MASSA Products
RECORDING SYSTEMS
ACCELEROMETERS
MICROPHONES
HYDROPHONES
TRANSDUCERS

IRE SHOW
Booth Nos.
3609 to
3611

MASSA
A DIVISION OF
COHU
ELECTRONICS, INC.

8 FOTTLER ROAD
HINGHAM, MASSACHUSETTS

CIRCLE 207 ON READER SERVICE CARD

WHAT'S NEW

Chance Vought Moves Fast Into the Control Field

Following a well-laid plan, this old line airframe company has set up one process control firm, bought control of a data processing outfit, and now merged a leading control company.

—LOS ANGELES

In a series of complex corporate maneuvers involving no less than two acquisitions and the formation of a new company, Chance Vought Aircraft, Inc. of Dallas has left no doubt of its determination to cut itself a big chunk of the computer and process control fields.

Late in January (as reported in CtE's "Newsbreaks", Feb. '60, p. 19) CVA negotiated an agreement to acquire Panellit, Inc. and Information Systems, Inc. of Skokie, Ill. ISI had acquired substantially all of Panellit (its parent company) for $3.75 million and assumption of Panellit's liabilities. Eighty percent of the combined firms were then bought by Vought. This combination of outfits, along with Genesys Corp., a wholly-owned subsidiary of CVA located in Los Angeles, was then named a new ISI under CVA control. Panellit and Genesys are separate operating units.

ISI makes a 609 computing system for process control that is built around the Elliott 803, a general purpose machine built by Elliott Brothers Ltd. of London. Panellit is well established as a maker of graphic panels, annunciators, and data loggers. (See Panellit-ISI story, Aug. '59, p. 52.)

Headquarters of the new ISI will be in Los Angeles, with the old ISI moving to join Genesys there; Panellit will stay in Skokie. Top men in the new CVA arm will be Gifford K. Johnson as president and chief executive officer and Albert F. Sperry as board chairman and acting as technical director. Johnson is a Vought v-p and president of Genesys; he's also chairman of CVA's second newest subsidiary, National Data Processing Corp. Sperry was president of Panellit and ISI.

• **A long range plan**—Diversification into commercial markets is not something new to Vought. "Several years ago", says Johnson, "Chance Vought started looking into diversification possibilities. This was almost as far back as 1954 when Vought was spun away from United Aircraft Corp."

First move came in May 1958 with the formation of Genesys to concen-

trate on a process control system.

Last October Vought took another giant step. It purchased the controlling interest in fast-growing National Data Processing Corp., a young (two-year old) Dallas firm which had carved out a surprising slice of the competitive business data processing field.

To buttress these expansions CVA got into the mobile home building business last December by acquiring General Coach Works, ABC Coach, and Mid-States Corp. Estimated 1959 sales of the three (now combined in Vought Industries, Inc.) are $60 million, making the company the leading mobile home builder in the nation.

• **Not sunk by Navy**—The wisdom in CVA's diversification scheme became evident rather early and in spectacular fashion late in 1958 as the firm received quick one-two punches in cancellations of production phases of the Navy's Regulus II missile and F8U-3 fighter plane.

This induced a profit slice: earnings in the first nine months of 1959 were down $4.3 million from $7.2 million for that period of 1958. The order backlog dropped to $310 million at of the end of September 1959 from $370 million at the end of 1958.

• **Everything in its place**—Besides diversifying in the commercial line, Vought has broadened its operations in the government area and set up new working groups. An Astronautics Div. handles space vehicle work, an Electronic Div. works on developing military systems in that field and is trying moves into air traffic control, an Aeronautics Div. handles all the remaining missile and aircraft business and is moving into anti-submarine warfare. Range Systems sets up test ranges, and a research center is in operation.

As for the new ISI, Johnson says, "I don't want to give the impression that we are acquisition-happy, but I certainly don't think that future growth will be entirely internal." He says that ISI will remain predominantly nonmilitary, but that it won't shy from any applications that fit into its capabilities. Johnson indicates that expansion may come from blending with Genesys' computer concepts. That group's engineers say they have some ideas that can be applied to the ISI computer that will make it useful beyond its present role.

ISI sales from March through November totaled $322,000. It has sold three of its 609's to du Pont, one to Gulf States Power Co., and one to Westinghouse. Panellit's sales through last November were $5,525,936.

Genesys is not as far advanced in computing-control as ISI. It has developed a special purpose digital com-

WHAT'S NEW

puter aimed primarily at process control; the first computer hardware will be shown in a few months. A study program to develop a process control computer for Sun Oil Co.'s Marcus Hook, Pa., refinery is just about to enter the hardware phase. Genesys also is supposed to have a proposal to control a major gas pipeline in the wind. Its billings for 1960 should be just shy of $1 million.

National Data Processing will operate separately from the two units of ISI. But since Johnson is board chairman at NDP, collaboration will probably result in some joint ventures.

• **CVA banishes skeptics**—NDP, though not widely known, had a good reputation in select circles for its equipment even before CVA moved into the picture last year. "We never did find any skeptics about our equipment," a young NDP executive said recently. "We did find some who had doubts about our future. We needed a well-known name behind us, and we needed financial backing. Since Vought moved into the picture, we aren't finding the skeptics."

NDP has had a $300,000 contract for a pilot installation in San Francisco of bank data processing equipment for the Federal Reserve System since before the CVA acquisition. Besides the complete NDP pilot installation, three of the other four installations will use the firm's encoders.

The other system that NDP is pushing is its Readatron credit invoice control system for processing point-of-transaction data.

NDP sees great promise also in its equipment for wire transmission systems (data converters, magnetic tape recorders, transmitter-receivers) and a versatile card reader.

—Kemp Anderson
—Marvin Reid
McGraw-Hill News

IMPORTANT MOVES BY KEY PEOPLE

Dr. John G. Hutton is new general manager of GE's Specialty Control Dept., filling the post vacated by Dr. L. T. Rader. Dr. Hutton has been with GE 17 years.

Dr. Leo Esaki, originator of the tunnel (or Esaki) diode, has joined IBM's Semiconductor Research Dept. as resident consultant.

James D. McLean has become president of the Stromberg-Carlson Div. of General Dynamics Corp. He's former president of Hoffman Labs.

ABSTRACTS

Fast multiplier

From "Use of a Diode Ring as a Four-Quadrant Multiplier", by R. H. Wilcox. Review of Scientific Instruments, November 1959, pp. 1009-1011.

Semiconductor diode ring multipliers offer a solution to many of the problems of high speed and high frequency analog multiplication because of their simplicity, small size and weight, ease of adjustment, freedom from unreliable components, and low drift rate over long periods of time. Such a multiplier is subject to some limitations, and these the author discusses after analysis of the basic circuit.

The multiplier is based on the relation,

$$xy = \tfrac{1}{4}[(x + y)^2 - (x - y)^2]$$

and uses semiconductor diodes to accomplish this function. The current through a semiconductor diode is:

$$i = A(e^{\gamma v} - 1)$$

where v is the impressed voltage, A and γ are parameters of the particular diode, and e is the Naperian base. Four such diodes, assembled as a ring circuit as shown in the figure, form the multiplier. Here, e_1 and e_2 are the inputs and e_o is the output. Using two assumptions—the source impedances (made true by design) and the four diodes have identical characteristics (approached by careful selection)—the author analyzes the circuit using Kirchhoff's laws. The resulting equation:

$$e_o = (4/3)A\gamma^2 R e_1 e_2$$

shows the theoretical ability of the circuit to perform multiplication.

To obtain matching current-voltage characteristics, it is only necessary to select diodes with similar values for the parameters A and γ. These can be measured by impressing two voltages, one twice the other, and measuring the resulting current. The parameters are then found from:

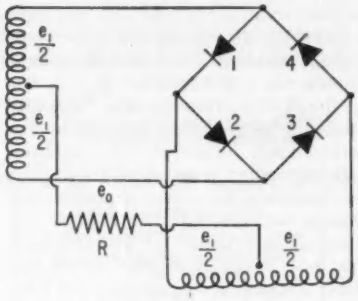
$$A = \frac{i_1}{e^{\gamma v_1} - 1} \text{ amp}$$

and

$$\gamma = \frac{1}{v_1}\left(\ln \frac{i_2 - i_1}{i_1}\right) \text{ volts}^{-1}$$

Using four matched diodes, a multiplier was constructed. The same signal (1600 cps) was fed to both inputs. A plot of relative output amplitude vs input (mv) showed that the output was essentially the square of the input.

However, depending on the load impedance, the relationship deviated from its squareness characteristic above certain input voltages. For instance, with load impedance of 200,000 ohms, the output retained its squareness up to 100-mv input. With 500 ohms, the range extended up to about 250 mv. The limiting factor in extending the input range is the diodes' back current, which increases rapidly above several hundred mv.



Ring multiplier

In a concluding section the author discusses the effects of nonidentical A's and γ's and of missetting transformer center taps. Temperature and other environmental effects were not investigated since the circuit provided good repeatability in spite of uncontrolled conditions. The upper frequency limit to ring multiplier operation depends on the diodes themselves, 1,200 Mcps being obtained in an early (1954) design.

Installing electronic controls

From "Integration of Electronic Controls with a Data System in a Plant Modernization Program" by C. E. Greef, E. I. du Pont de Nemours & Co. Paper presented at the 14th annual Instrumentation-Automation Conference of the Instrument Society of America, Chicago, Ill., September 21-25, 1959.

The electronic instrument installation posed some problems partly because of our lack of familiarity with a large scale electronic installation. . .

The design of the power transmission wiring was our first problem. Three basic wiring concepts were considered. First was a system in which all transmitters received their power from the control room receiving instrument. This proved unsatisfactory because of the large number of transmitters (¾ of the total) which did not terminate at a receiving instrument and the anticipated high cost of individual runs averaging 550 feet for instruments that might be grouped together in large numbers and could

ABSTRACTS

be supplied from common sources. The second possibility was to use local electrical supplies for the transmitters. This would make the system unduly complicated because this source would be needed for the control room instruments and might result in signals of different phase relationships in the control room. It would also preclude a single standby emergency power supply. The power transmission system chosen was one which supplied power to the field instruments and the corresponding panel instruments from the same circuit. Without requiring separate continuous power wiring from the control room to each transmitter, the system was divided into enough circuits so that failure or shut-down of any one would not shut down the plant. Signal wiring approached telephone type of installation, using crimped connections in the field distribution boxes and multipair cables between the main terminal box in the control room and the field distribution boxes. All grounding was done at the main terminal box.

The second design decision involved type of emergency power supply required. Investigation of the reliability of electrical feeders on the plant indicated only a remote possibility of all feeders failing simultaneously. It was decided to reduce the chance even further by tying to the emergency generator feeder for instrument power and adding automatic transfer to another feeder in case of failure of this supply. In order to prevent interlocks from shutting down the plant during such a transfer, an induction-motor-fly-wheel combination is continuously idling and supplies power to the instrument system during transfer switching. This system has resulted in switching with no noticeable voltage dip.

Briefly noted

From "Resistance Diode Bridge Circuit for Temperature Control", by L. H. Bennett and V. M. Johnson, National Bureau of Standards Technical Note 34, Oct. 1959. Available from Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D.C., as PB 151393, 5 pp., $0.50.

The conventional ac bridge gives irregular performance, including loss of temperature control, when the temperature error exceeds a certain critical value. The note describes a simple way to achieve stable temperature control over a wide range of temperatures.

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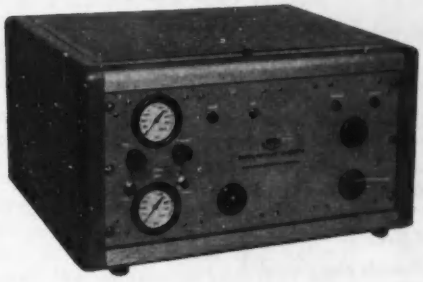

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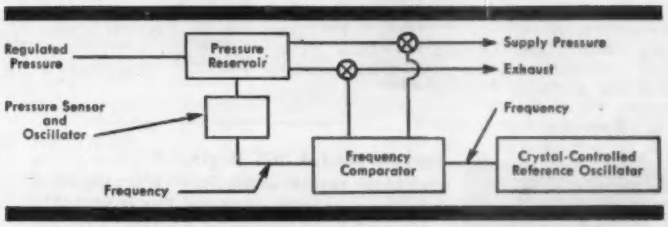

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NEW BOOKS

Computer Primer

DIGITAL COMPUTING SYSTEMS. *Samuel B. Williams. 229 pp. Published by McGraw-Hill Book Co., Inc., New York. $7.75.*

This is a broad technical introduction to digital computing systems, especially written for readers with engineering backgrounds and others familiar with electrical circuits and apparatus. Coverage ranges from coding and components to computer applications. The book describes the various elements contained in modern computers, explaining the underlying principles of the devices used and illustrating the devices themselves. The circuitry by which the elements are made to perform desired functions is clearly covered, with many examples of typical circuits. Logical design and programming are discussed in realistic terms. A brief picture of how digital computers can be used to help solve scientific, business, and data handling problem is presented.

Know Your Process

ELECTROANALYTICAL CHEMISTRY. *Dr. James J. Lingane. 669 pp. Published by Interscience Publishers, Inc., New York. $14.50.*

Developments in the field of electroanalytical chemistry during the past five years amply justify this second edition of Lingane's well-known book. As in the first (1953) edition, the author, following a brief but informative introductory chapter, presents a broad treatment in an admirably thorough manner.

Among the subjects covered are galvanic cells; the measurement of pH; potentiometric titrations of the acid-base, precipitation, oxidation-reduction, and automatic types; conductometric analysis; electrolysis; electrical instrumentation for controlled potential electrolysis; controlled potential electrogravimetric analysis; controlled potential electrolytic separation of metals prior to other methods; internal electrolysis; electrographic analysis; and controlled potential coulometric analysis.

Several new chapters include those devoted to electrical measurements common to all electroanalytical techniques, polarography, amperometry, amperometric titration, and chronopotentiometry. Two new chapters reflect modern thinking with respect to theory, instrumentation, technique, and applications of coulometric titration. Chapter III, "Interpretation of

NEW BOOKS

the E. M. F. of Galvanic Cells", closes with fifteen excellent problems that are thoughtfully fortified with answers. Doubtless some users of the book would like to see similar problems in other chapters.

One valuable new feature is the appendix, which lists standard and formal potentials, largely from Latimer's "Oxidation States of the Elements and Their Potentials in Aqueous Solution", Prentice-Hall, 2nd edn., 1952, for 335 important reactions.

The author writes with sound appreciation of the needs of the reader and sympathetic realization that few are as familiar with the subject as he is. The material is well-organized; the 148 figures are impeccable from drafting and photographic standpoints. Many of the figures bear descriptive legends that are more helpful than are mere titles. The numerous chemical equations are clearly presented and mathematical derivations are supplied in sufficient and well-balanced detail. Documentation appears to be thorough; a good subject index is provided and the typography is excellent.

D. S. Davis
University of Alabama

Basis for Choice

BUSINESS EXPERIENCE WITH ELECTRONIC COMPUTERS. *B. Conway, J. Gibbons, and D. E. Watts.* 191 *pp. Published by Controllers Institute of America, New York.* $5.

This book is aimed principally at those who have the responsibility for deciding initially on whether or not to buy electronic data processing equipment and then for planning and supervising the electronics program itself. It draws on the experience of a number of prominent companies with extensive computer departments. Major sections are devoted to making the decision, preparing for and introducing electronic equipment, and operating the system.

New Approach

ANALYSIS OF ELECTRIC CIRCUITS. *Egon Brenner and Mansour Javid.* 702 *pp. Published by McGraw-Hill Book Co., Inc., New York.* $9.50.

This introduction to linear electric circuit analysis on the sophomore-junior level assumes a knowledge of calculus, but does not introduce advanced mathematics. An integrated treatment of network response is provided in this text by the early intro-

NEW BOOKS

duction and application of the notion of complex frequency, network functions, and their poles and zeros without sacrificing conventional skills, such as the solution of ac circuit problems. The analytical and graphical skills are useful not only in the application of electronic and power circuits, but also in advanced study of linear system analysis and synthesis.

Instead of the traditional division of circuit analysis into dc circuits, ac circuits and transients, the treatment regards dc and ac circuits as important but special cases of circuit response. This general approach is made possible by first studying the simple circuits in detail. As a result, transients are not studied as a subdivision of circuit analysis but are integrated into the general problem of "response calculations". Thus from the outset the relationships between transient and steady-state response are made clear. The time domain behavior of circuits is emphasized so that the terms impedance and admittance have a broader meaning than in traditional books. In the chapter concerned with network functions, both driving point and transfer functions are introduced.

WHAT'S AVAILABLE IN REPRINTS

The following reprints have been prepared to make important reference-type editorial material available to CONTROL ENGINEERING readers in convenient filable form. Some reprints are individual articles, while others are "packages"—several articles published over a period of time that logically supplement one another in the coverage of a specific phase of the control field. Any reprint can be obtained at the nominal cost listed below by filling in the order form and sending it, together with remittance, to Readers Service Dept. Quantity rates will be quoted on request.

How to Specify Instrument Accuracy, 8 pp. This basic reprint is aimed at helping the user and maker to develop clear and mutual agreement on allowable instrument errors. Discussions of uncertainties of zero, scale factor, and instantaneous slope aid in the intelligent specification of allowable errors and preferred test procedures. 40 cents.

Transparent Template for Designing Servo Compensators, November 1959, 3 pp. plus template. Includes transparent decibel vs phase angle template on clear acetate in addition to three-page Data File outlining development of template and showing its use through sample problem. 75 cents.

How to Use the Root Locus in Control System Design, 12 pp. Another reprint that translates theory into practice. Eight simple rules make locus construction easy, even including the effects of distance-velocity lags. Articles show how to interpret the locus diagram, how to

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determine transient response, and how to use locus techniques with multiloop systems. 45 cents.

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Analysis Instrumentation—III—Electrochemical Methods, Mass Spectrometry, Continuous Viscometers, X-Ray Techniques, K-Capture, Physical and Chemical Property Testers, Emission Spectroscopy, 48 pp. Reprint includes last nine articles of Analysis Instrumentation Series. $.90.

Analysis Instrumentation – II – Refractometers, Infrared Analyzers, Photometric Analyzers, Colorimetry, 32 pp. This includes the second group of four articles of the Analysis Series. 60 cents.

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Fundamentals of Multivibrators, 12 pp. Multivibrators are the electronic equivalent of the double-throw electromechanical relay and can perform substantially the same functions (memory, logic, gating, counting), but at enormously higher speeds. They can be built around vacuum tubes, transistors, square-loop magnetic materials, neon tubes, thyratrons, and cryotrons. This reprint covers a broad selection of multivibrator circuits that are especially applicable to control systems. 45 cents.

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Survey of Ac Adjustable-Speed Drive Systems, June 1959, 16 pp. Largely regarded as constant-speed devices, multispeed ac actuators actually take many efficient forms. The recent resurgence of interest in these ac adjustable-speed systems prompted this comprehensive coverage of pole-changing techniques, armature resistance control of wound-rotor motors, frequency changing, slip-frequency injection, and the use of eddy-current couplings. 50 cents.

A New Way to Select the Best Control Valve, 16 pp. This three-article reprint takes a fresh look at the problem of specifying process flow control valves. The author gives rules for selecting the right valve characteristics based on static and dynamic considerations, takes into account the influence of piping on valve performance, and tackles the problem of sizing valves for maximum flow and for control rangeability. 50 cents.

Continued on page 222

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Fundamentals of Tie-Motor Control, 12 pp. Although high-powered synchro-tie systems have been around for a long time, only recently has enough experience been logged to put their design on a scientific, rather than cut-and-try, basis. This reprint examines the types of motors that can be used in the light of the application characteristics, and considers the special circuit designs that are required. 30 cents.

Applying Phase-Plane Techniques to Nonlinear System Design, 16 pp. This series of three articles is designed to teach the use of phase-plane techniques to working system designers, on a practical rather than theoretical basis. It tells how to construct a phase-plane plot, how to interpret a plot in terms of system performance, and how to synthesize nonlinear systems using phase-plane techniques. 50 cents.

Economics in Control, December 1958, 24 pp. A special report covering the economic aspects of modernizing with control systems. It starts off with a guide to the financial factors of modernization, then tells the control engineer how to spot opportunities where the addition of instrumentation and control equipment will earn money, and concludes with nine case histories showing specific benefits of modernizing with control systems. 50 cents.

First-Hand Report on Control Inside Russia, November 1958, 16 pp. A team of 14 U. S. control engineers representing the American Automatic Control Council reports on the status of automatic control in Russia. Each expert gives impressions of progress in his field of interest based on visits to Russian user plants and research facilities. 40 cents.

How to Calculate a Control Earning Index, 12 pp. Shows a four-step method for predicting the increment of improved plant economy resulting from the addition of instruments and controls, and reports on experience in applying this method to three typical industrial processes. 30 cents.

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MEETINGS

MARCH

American Society of Mechanical Engineers, Hydraulic Division Conference (held jointly with Gas Turbine Power Conference), Rice Hotel, Houston, Tex. March 6-9

Instrument Society of America, Temperature Measurement Symposium, Deshler Hilton Hotel, Columbus, Ohio March 9-11

Synchro Design and Testing Symposium, Dept. of Navy, Bureau of Naval Weapons, Dept. of Commerce Auditorium, Washington, D. C. March 17-18

Institute of Radio Engineers, National Convention, Coliseum and Waldorf-Astoria Hotel, New York City March 21-24

Instrument Society of America, Tenth Annual Iron and Steel Conference, Pick-Roosevelt Hotel, Pittsburgh, Pa. March 23-24

22nd Annual American Power Conference, sponsored by Illinois Institute of Technology, Hotel Sherman, Chicago, Ill. March 29-31

APRIL

Sixth Nuclear Congress, sponsored by ISA and Engineers Joint Council, New York City April 3-8

Instrument Society of America, Symposium on Computers in the Process Industry, sponsored by N. J. Section, Hotel Essex House, Newark, N. J. April 5

Third National Chemical and Petroleum Instrumentation Symposium, Rochester, N. Y. April 5-7

American Institute of Electrical Engineers, First Special Conference on Electrical Engineering in Space Technology, Baker Hotel, Dallas, Tex. April 11-13

Conference on Automatic Techniques, sponsored by IRE, AIEE, ASME, Sheraton Cleveland Hotel, Cleveland, Ohio April 18-19

Institute of Radio Engineers, Southwest Regional Conference and Electronics Show, Shamrock-Hilton Hotel, Houston, Tex. April 20-22

Texas A&M Symposium on Instrumentation, Campus, Bryan, Tex. April 20-22

American Society of Tool Engineers, 1960 Tool Show, Detroit, Mich. April 21-28

MAY

Institute of Radio Engineers, 12th Annual National Aeronautical Elec-

MEETINGS

tronics Conference, Dayton, Ohio May 2-4

Instrument Society of America, Sixth National Flight Test Instrumentation Symposium, Hotel Del Coronado, San Diego, Calif. May 2-5

Western Joint Computer Conference, sponsored by IRE, AIEE, ACM, Jack Tar Hotel, San Francisco, Calif. May 3-5

National Association of Relay Manufacturers, Eighth Annual Conference, Oklahoma State University, Stillwater, Okla. May 3-5

Instrument Society of America, Third National Power Instrumentation Symposium, San Francisco, Calif. May 9-11

Instrument Society of America, Instrument-Automation Conference and Exhibit, Brooks Hall, San Francisco, Calif. May 9-13

American Society for Metals, Second Southwestern Metal Congress and Exposition, Sheraton Dallas Hotel, Dallas, Tex. May 9-13

Electronic Components Symposium, sponsored by IRE, AIEE, EIA, WEMA, Washington, D. C. May 10-12

American Material Handling Society, Third Western Regional Material Handling Show and Packaging Cavalcade, Great Western Exhibit Center, Los Angeles, Calif. May 11-13

Superconductive Techniques for Computing Systems Symposium, sponsored by Office of Naval Research (Information Systems Branch), Dept. of Interior Auditorium, Washington, D. C. May 17-18

American Society of Mechanical Engineers, Production Engineering Conference, Hotel Schroeder, Milwaukee, Wisc. May 17-19

American Society of Mechanical Engineers, Oil and Gas Power Conference and Exhibit, Muehlebach Hotel, Kansas City, Mo. May 22-26

Ninth National Telemetering Conference, Miramar Hotel, Santa Barbara, Calif. May 23-25

American Society of Mechanical Engineers, Design Engineering Conference and Show, Statler-Hilton Hotel, New York May 23-26

International Instruments, Electronics, and Automation Exhibition, Olympia, London, England May 23-28

Conference on Automatic Computing and Data Processing in Australia, University of Sydney, University of New South Wales May 24-27

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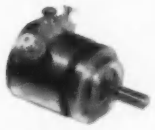
Type MFR — encapsulated contact patented Metlfilm, ultra-reliable, long life potentiometers.



PVR05

PVR09 (ganged)

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Type PVR — new, complete line of low torque, high accuracy, performance proved, servo type precision potentiometers.

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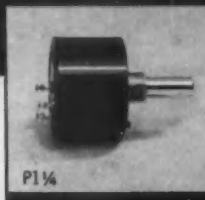
Type C10-09 — 10 turn, may be ganged.

RVBC2

Type RVBC2 — unitized construction for development work.



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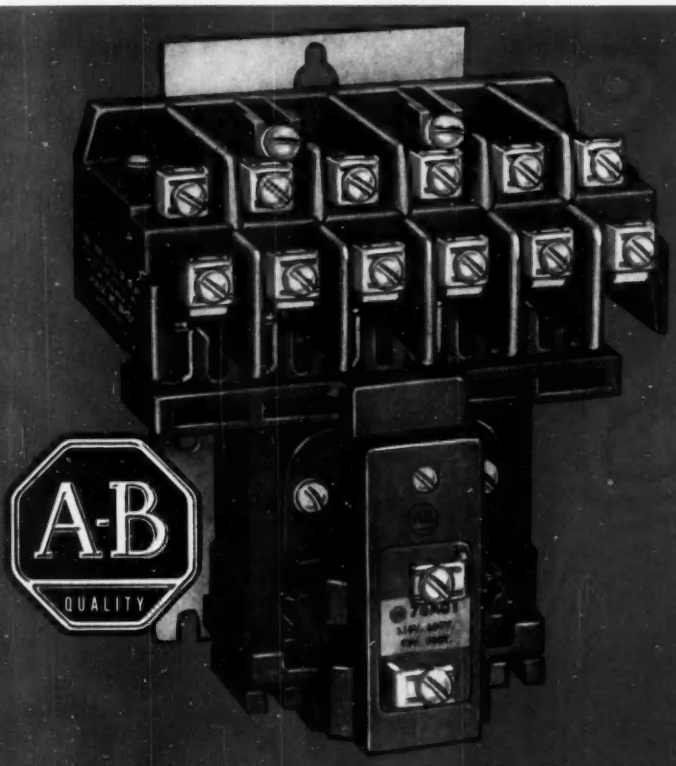


Bulletin 700 Type BR Relay—all six poles arranged with normally open contacts.

Allen-Bradley Convertible Contact CONTROL RELAY

BULLETIN 700

TYPE BR

Changeover made in seconds!

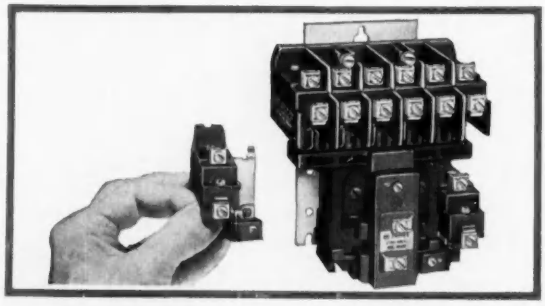
The contacts of the new Type BR relay can be arranged for either normally open or normally closed operation—and any changeover in the field can be made in seconds. A screwdriver is all that's needed.

This new A-B Bulletin 700 Type BR relay is ideal for use on automatic machines where control functions are frequently altered to meet production changes.

Quick convertibility of the contacts enables easy "on-the-spot" changes—from "normally open" to "normally closed"—or vice versa.

These new Bulletin 700 Type BR relays have been exhaustively tested to make sure that they will provide the many millions of trouble free operations for which all A-B controls are famous. In fact, the Bulletin 700 Type BR relays will establish new standards for long relay life and "reliability" of contact operation. Of course, they have double break, silver contacts that never need attention; also, the cast-plastic coil is impervious to the most severe atmospheric conditions.

Please write for full details, today!



Two extra convertible poles can be easily added—in the field

An auxiliary convertible contact pole—having full switching capacity—can be easily added to the left and right sides of the Type BR relays. These auxiliary poles are front-mounted and can be added without disturbing the wiring of the relay—and without removing the relay. All relays are designed to also accept stab connectors, and—all terminals are accessible from the front.

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